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ORIGINAL ARTICLES.

I.—The Earliest Geological Maps of Scotland and Ireland.

By Professor J. W. Judd, C.B., LL.D., F.R.S., V.P.G.S., etc.

THE first geological map of Scotland has a history not less interesting than that of Smith's famous map of England; seeing that what Smith accomplished, single-handed, for the southern part of Britain, John Macculloch did, with the same independence of all extraneous aid, for the northern half of the Island. Smith's fame has happily been long since vindicated; but, owing to a variety of circumstances, Macculloch has never received full credit for his grand work; on the contrary, his fair name and even his veracity have been too often cruelly aspersed. Macculloch, though of Scotch descent, was born in the Channel Islands, and educated first in Cornwall and afterwards as a medical student in Edinburgh. He was an excellent chemist and mineralogist, and brought to the study of geological problems an amount of exact scientific knowledge rare in those who at that day turned their attention to the subject. Commencing life as an Army-surgeon, he in 1803, when thirty years of age, was made Chemist to the Board of Ordnance, though the appointment did not prevent him from practising privately as a medical man at Blackheath from 1807 to 1811. In the latter year, however, he gave up medical work and was sent to Scotland to make inquiries as to the best rock suitable for powder-mills. Subsequently, a Commission was formed to ascertain what mountain in Scotland would prove most suitable for experiments similar to those carried on by Maskelyne at Schiehallien, to determine the earth's density.

In this way Macculloch was led to spend much time in travelling about Scotland and in studying the rocks of the country, and between the years 1811 and 1821 he each year devoted portions of every season to geological work in the North. In 1814 he received the appointment of "Geologist to the Trigonometrical Survey," a post to which it had been proposed, as we have already seen, to appoint William Smith in 1805.

John Macculloch was an original member of the Geological Society, and soon became one of the most active workers in it. His paper entitled "Account of Guernsey and the other Channel Islands" was the first which was honoured with a place in the Transactions of the Society, and many other valuable memoirs from his pen found

a place in succeeding volumes. Macculloch was the fourth President of the Geological Society, occupying the Chair from 1816 to 1818. In 1819 Macculloch published, in two volumes with an Atlas, his "Description of the Western Islands of Scotland, including the Isle of Man, comprising an Account of their Geological Structure, with Remarks on their Agriculture, Scenery, and Antiquities." The maps and sections of this work must be admitted to be of extraordinary merit, when the imperfect topographical data at the author's disposal are taken into account. His sections, illustrating the relations of igneous to stratified rocks, are of great value, and exhibit a very marked advance on anything of the kind that had ever been produced before.

In 1826 Macculloch, who had collected a vast mass of information concerning the geology of Scotland, received a commission from the Lords of the Treasury to construct a geological map of the country. While he was thus employed, Macculloch received a regular salary from the Government, and, when the map was completed, it was engraved and coloured by the order and at the cost of the Treasury. Macculloch finished the field-work in 1832, and by the middle of 1834 the coloured map was ready for publication, and was, with accompanying memoirs, sent in to the Treasury.

Unfortunately, however, various circumstances seem to have delayed the publication of the work. There being no Ordnance Map of Scotland at the time, Macculloch was compelled to employ the best private map which then existed—that of Arrowsmith—on which to insert his geological work. All who have endeavoured to do any serious geological mapping in Scotland, before the publication of the Ordnance Map, will sympathize with Macculloch in his disappointments—frequently verging on despair—in trying to adequately represent the geological structure of the country on such an imperfect topographical basis as that of Arrowsmith's Map. Macculloch's Geological Map of Scotland, which has recently been characterized by a very high authority as "perhaps the most remarkable achievement of the kind which up to that time had been accomplished by a single individual," long remained almost unknown to and neglected by geologists. In 1851 Murchison referred to it as being "usually known as Macculloch's Map," and as being "so replete with errata that it would be a waste of time to attempt to enumerate them."

Macculloch belonged neither to the school of the Neptunists nor to that of the Plutonists, and not to take a side in those days of embittered controversy was in itself almost accounted a crime. In the accuracy of his mineralogical and petrographical knowledge, and in his insistence on the importance of such knowledge to the field-geologist, he resembled the disciples of Werner; but by the accuracy of his description of the relation of igneous to sedimentary masses he did more than any other geologist to confirm and establish the principles so well shadowed forth by Hutton. When William Smith's teaching of the value of fossils in classifying strata had spread, so as to meet almost universal acceptance among geologists

south of the Tweed, Macculloch unfortunately found himself too old, too conservative, and too opinionated to accept the new views and to give them the welcome which they deserved.

In spite of omissions and defects, which it would be easy to point out in any great pioneer work of the kind, Macculloch's Map is a splendid production, and all subsequently published maps of the country have been based upon it. In one important respect the map, as finally published, did not do justice to Macculloch's acumen and research. As is well known, he very early made out the true relations and age of the Torridon Sandstone and its infraposition to the Durness Limestone, in which latter rock he was the first to detect fossils. Murchison and Sedgwick, however, vehemently opposed his views, maintaining that the Torridonian was nothing but Old Red Sandstone faulted down; and, in deference to their authority, Macculloch allowed his earlier and correct interpretation to fall into abeyance.

If we seek for the causes of the neglect and injustice with which John Macculloch's great work has been so long treated, they are not difficult to discover. In the first place, Macculloch, excellent mineralogist and able geologist as he undoubtedly must be admitted to have proved himself, was a man with many eccentricities of character—some of them not of the most amiable kind—and he became extremely unpopular during the later years of his life. In England, and especially among his earlier associates of the Geological Society, his contempt, strongly felt and often offensively expressed, for "mere amateurs" could scarcely tend to make his company agreeable in circles where geology had been so widely cultivated by unprofessional workers.

In Scotland, a supposed want of patriotism, indicated by a tendency to point out faults in the national character of the Highlanders, was a characteristic of Macculloch which made him the subject of the most rancorous attacks. Embittered by this isolation, and smarting under what he regarded as the undeserved neglect of his work and the unmerited aspersion of his character, Macculloch in some of his later works assumed an air almost of omniscience, and poured unmitigated contempt on all advances in geological science in which he had not taken a share. Macculloch died as the result of a carriage accident in Cornwall within a year of the completion of his map, and when it was only just on the point of being issued to the public. The earliest copies published bore the imprint "A Geological Map of Scotland by Dr. MacCulloch, F.R.S., etc., etc. Published by order of the Lords of the Treasury, by S. Arrowsmith, Hydrographer to the King"; and one such copy, originally the property of the late John Phillips, which came into my possession on the death of that geologist, I have handed over to the Geological Society, where it is preserved, side by side with the immortal work of Smith. But the title and description of the map were unfortunately merely engraved on a loose sheet to be pasted over the title of the topographical map; and, after the death of Macculloch, this description was, either by accident or design, usually omitted, and the

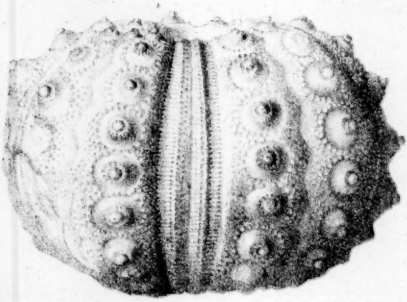
geological map was issued as though it were the work of Arrowsmith. It must certainly be admitted that Macculloch's strictures on the topography of the map were of such a character as to be only too well calculated to produce resentment in the minds of the publishers.

From this sketch of the history of Macculloch's Geological Map of Scotland, it will be seen that the first Government Geological Survey carried on in the British Islands was that of Macculloch. It is often said that the work of the Government Survey originated in the grant of £300 per annum made to De la Beche in 1832 to aid him in his labours in the South-West of England. But as we have seen, Macculloch was in 1814 appointed Geologist to the Trigonometrical Survey, and in 1826 was commissioned and paid by the Treasury to make a regular survey of the country; and his map finished before the date of the first grant made to De la Beche was published at the national expense. This first geological survey of Scotland by Macculloch has therefore just the same right to be regarded as a Government Survey as the second survey of the country which was commenced in 1854 by the late Sir Andrew Ramsay, and is now being carried on by many workers with such admirable skill and energy.

James Nicol's Geological Map of Scotland—a work of great merit—which was issued about 1846, bears much the same relation to Macculloch's map that Greenough's map does to that of Smith's. Nicol's work could not have been executed had not Macculloch's map been in existence, but the younger geologist was able from his own investigations, and by collecting and incorporating the work of many fellow-labourers in the same field, to make his map of Scotland a much more complete and trustworthy work than the original of John Macculloch.

The Geological Map of Ireland by Sir Richard Griffith is well worthy of taking a place side by side with Smith's England and Wales and Macculloch's Scotland. Griffith, who, though born in Dublin, received his scientific training in London and Edinburgh, entered the Government service as an Engineer and Surveyor in 1809, when only twenty-five years of age. For nearly fifty years he was constantly employed, travelling in all parts of the country, examining bogs, mines, and agricultural properties, carrying on the "Perambulation or Boundary Survey of the parishes, baronies, and counties," and making that assessment of the land so well known as "Griffith's Valuation."

In 1812, when Greenough laid the first draft of his Map of England and Wales before the Geological Society, he appears to have pressed upon the attention of his friend Richard Griffith the desirability of undertaking a similar work in Ireland, and in the summer of that year the first draft of such a map was made by Griffith with the aid of notes supplied by Greenough. This draft appears to have been continually added to and improved down to the year 1821, when a proposal for its publication was made by the author in a letter to the Royal Dublin Society. Nothing, however, came of this proposal; and it was not till 1835, when



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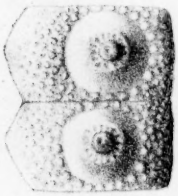

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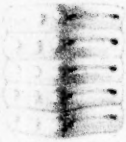

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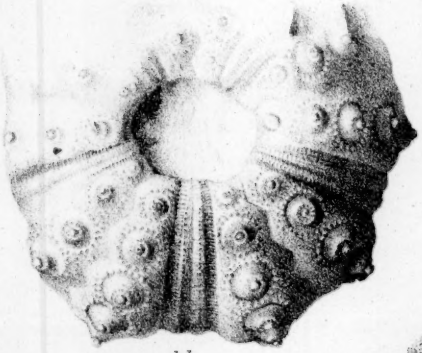

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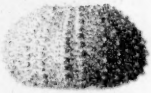

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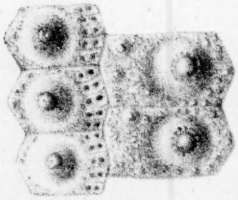

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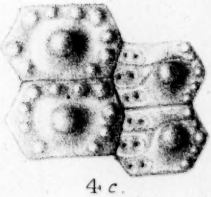

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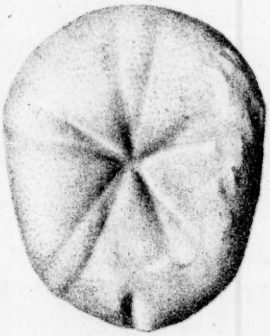
G.M. Woodward del. et lith. West, Newman imp.

Egyptian Echinoidea.

3×5



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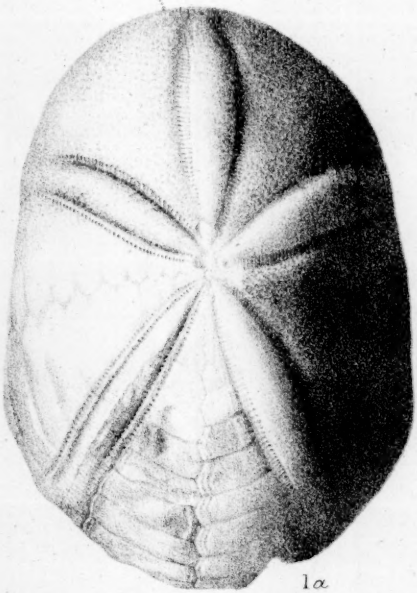

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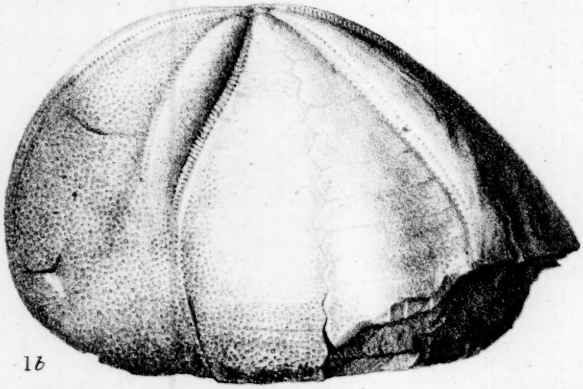

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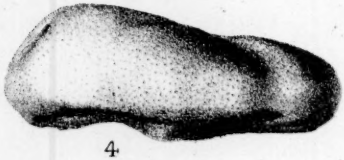

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G. M. Woodward del. et lith. West, Newman imp.

Egyptian Echinoidea.

Griffith was President of the Geological Section of the British Association at the Dublin Meeting, that he was able to publicly exhibit in a complete form his Geological Map of Ireland. In the following year, the Irish Government ordered this map to be reconstructed and engraved on a scale of one inch to four miles by the Board of Ordnance. Before the map could be issued, however, Griffith drew up for the Railway Commissioners a work entitled an "Outline of the Geology of Ireland," which contained a reduction of his map, with many of the details omitted. This small map, which was issued in April, 1838, must be regarded as the first complete geological map of Ireland that was regularly published. I have not been able to ascertain whether any of Griffith's earlier manuscript maps are in existence. In August, 1838, the large geological map of Ireland appears to have been exhibited at the British Association Meeting in Newcastle; but it was not regularly published till March, 1839. A second edition of the map was published in 1855 by order of the Treasury.

The Wollaston Medal, which was in 1831 awarded to William Smith for his Geological Map of England and Wales, was in 1854 presented to Sir Richard Griffith for his Geological Map of Ireland. The three pioneer Geological Maps of England, Scotland, and Ireland have now been placed in juxtaposition in the geological gallery of the Science Division of the South Kensington Museum, where they are open to examination and comparison with the earliest geological maps published in France and other countries. A study of these maps will serve to demonstrate the priority claimed, and justly claimed, by Fitton, for the geological maps of this country over those of any other part of Europe.

The Geological Map of the Basin of Paris by Cuvier and Brongniart was published in 1810, while William Smith's early maps had appeared in 1799 and 1801; and the maps of England, Scotland, and Ireland, by Smith, Macculloch, and Griffith respectively, were published in 1815, 1835, and 1838, the first complete Geological Map of France, that of Elie de Beaumont and Dufrenoy, making its appearance in 1840.

II.—A Collection of Egyptian Fossil Echinoidea.

By J. W. Gregory, D.Sc., F.G.S.

(PLATES V AND VI.)

THE first collection of Egyptian fossils sent for determination by Captain Lyons, R.E., Director of the Egyptian Geological Survey, to the British Museum, includes an interesting series of Echinoidea, which has been intrusted to me for examination. It is hardly necessary to state that our knowledge of the fossil echinid faunas of Egypt is mainly due to M. P. de Loriol-le-Fort, who has described a large series in two admirable monographs.[1]

[1] P. de Loriol, "Monographie des Échinides contenus dans les couches nummulitiques de l'Egypte": Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii (1881), pp. 59–148, 11 pls. "Eocaene Echinoideen aus Aegypten und der libyschen Wüste": Beitr. Geol. Pal. libysch. Wüste, Abth. ii, Ht. 1, Palæontogr. Suppl., 1883, pp. 1–59, 11 pls.

The echinids in the Egyptian Geological Survey Collection include 79 specimens, which are referred to 15 genera and to 30 species, of which three are new. The horizons are known in each case, but the localities are not stated for one set, which apparently belong to an old collection preserved in the Cairo Museum.

The horizons represented are as follows:—

Pleistocene.
Middle Miocene—Helvetian Series: Siuah.
Upper Eocene—Bartonian Series.
Middle Eocene—Mokattam Series.
Lower Eocene—Libyan Series.
Cretaceous—Turonian.

Genus RHABDOCIDARIS, Desor, 1856.

1. Rhabdocidaris Libyensis, n.sp.

Diagnosis.

Test large and depressed; width much greater than the height. The shape is decagonal, with the sides all concave. The ambulacral areas occupy deep depressions, while the central suture of the interambulacral areas is also depressed.

Interambulacra.—Each vertical series consists of nine or ten plates. The tubercles are very prominent, the bases are perforated, and the mamelons strongly crenulate. The scrobicular areas are not confluent, but separated by one or two lines of granules. The scrobicular circles are well developed, the granules being much larger than those covering the rest of the plates. The tubercles are separated from the ambulacral suture by a series of small crowded granules, of which there are four or five rows at the ambitus. The granulated area between the tubercles and the median interambulacral suture is about twice as wide as on the other side; it is ornamented at the ambitus by six or seven rows of granules.

Ambulacral plates.—About eleven correspond to an ambital interambulacral plate. The pores of each pair are very wide apart, but are connected by a well-developed groove. The granular area down the middle of the ambulacrum is wide, and consists of two large and one or two small granules on each ambulacral plate.

Apical area large, pentagonal.

Dimensions.

		mm.
Height of test	... ...	35
Diameter of test	... ...	54
Diameter of apical system	... ...	18
Ambulacrum: width of poriferous zone at ambitus	...	2
width of interporiferous zone at ambitus	...	4
Interambulacrum: height of ambital plate	... ...	7
width of ambital plate	... ...	13
width of median granulated area of interambulacrum at ambitus	...	4

Distribution.—Lower Eocene—Libyan Series: near Assiut; Coll. Geol. Surv. Egypt, No. 629.

FIGURES.—Pl. V, Fig. 1*a*, test from the side; *b*, from above. Fig. 1*c*, two ambital interambulacral plates, × 2 diam. Fig. 1*d*, two ambital ambulacral plates, × 4 diam.

AFFINITIES.—This echinid is most nearly allied to *Rhabdocidaris itala* (Laube),[1] which has been described from the Egyptian Eocene by M. de Loriol-le-Fort. The principal difference between them is that in *R. itala* the tubercles are non-crenulate, whereas in *R. Libyensis* they are strongly crenulate. The tubercles are also taller. The shape of the test is more like that of *R. Zitteli*, Lor.,[2] but in that species the granulated areas of the interambulacra are much more restricted.

The third echinid with which it must be compared is *Porocidaris Schmideli* (Münst.),[3] with which it agrees in the crenulation of the tubercles. But the new species has not the slits around the bases of the mamelons; the interambulacral plates are much taller; in a British Museum specimen (No. 75,669) of *P. Schmideli* the height of the ambital plates is to the width as 9 : 13; and in *P. Schmideli* the epistroma consists of coarser and more uniform granules.

Genus PSAMMECHINUS, L. Agassiz, 1846.

1. PSAMMECHINUS DUCIEI, Wright, 1855.

SYNONYMY.—See Gregory, "Maltese Echinoidea": Trans. Roy. Soc. Edinb., vol. xxxvi (1891), p. 590.

DISTRIBUTION.—Up. Miocene—Tortonian: Malta. Mid. Miocene—Helvetian: Egypt; Coll. Geol. Surv. Egypt, No. 822.

There is a broken specimen of a *Psammechinus* in the collection which agrees in the characters shown with this well-known Maltese species. The granulation of an ambital plate of the Egyptian specimen is shown on Pl. V, Fig. 3. The species has not previously been recorded from Egypt. An allied African species is *P. Soubellensis*, Per & Gauth.,[4] in which, however, one tubercle on each interambulacral plate is much larger than the rest of the horizontal series.

2. PSAMMECHINUS LYONSI, n.sp.

DIAGNOSIS.

Test small; somewhat conical above, with tumid, well-rounded sides. Base flat. Seen from above the shape is sub-pentagonal, but with well-rounded angles.

Ambulacra.—Each ambulacral series consists of about thirteen plates, each of which bears a single conspicuous tubercle. The pore pairs are arranged in well-curved triplets. A double series of miliary granules runs down the middle of each area. The scrobicular areas of adjacent plates in the same vertical series are confluent.

[1] *Cidaris itala*, G. C. Laube, "Ech. vicent. Tert. Geb.": Denk. Ak. Wiss. Wien, vol. xxix, pt. 2 (1869), p. 9, pl. i, fig. 3.

[2] De Loriol, 1883, Beitr. libysch. Wüste, vol. ii, pt. 1, p. 8, pl. i, figs. 1, 11.

[3] *Cidarites Schmidelii*, Münster, in Goldfuss, Petref. Germ., vol. i, p. 120, pl. xl, fig. 4. De Loriol, 1883, op. cit., p. 9, pl. i, fig. 10.

[4] Peron & Gauthier, Ech. foss. Algér., vol. iii, fasc. 10 (1891), p. 252, pl. v, figs. 1-4.

Interambulacra of about ten plates in each vertical series. Each plate bears a prominent tubercle. The miliary granules are abundant and well developed. The scrobicular circles are complete, those on the upper border of one plate completing the circle of the plate above.

Peristome very large; branchial slits deep.

DIMENSIONS.

	mm.
Height of test	5·5
Diameter of test	9·5
Width of ambulacrum at ambitus	3·5
Width of interambulacrum at ambitus	2·3
Diameter of peristome	4·5

DISTRIBUTION.—Mid. Miocene—Helvetian: Egypt; Coll. Geol. Surv. Egypt, Nos. 977, 988.

FIGURES.—Pl. V, Figs. 4*a* and *b*, a test from the side and from below, × 2 diam. Fig. 4*c*, ambital plates, × 8 diam. Fig. 5, ambital plates of another specimen, × 8 diam.

AFFINITIES.—The species, by its unituberculate, multigranulate interambulacral plates, belongs to the series of species which Pomel grouped as the genus *Arbacina*; while by the deep, narrow branchial slits it is allied to the same author's *Oligophyma*.

Its nearest ally is *Psammechinus subrugosus*, Pomel,[1] from the Pliocene of Oran, in which the mamelon of the primary tubercles is much larger, there are some secondary interambulacral tubercles, and the ambital interambulacral plates are longer.

Psammechinus lævior, Pomel,[2] from the same deposits, has a more scanty epistroma.

The specimen illustrated by Pl. V, Fig. 5, resembles the *Arbacina asperata*, Pomel,[3] from the Pliocene of Oran, but in that form the tubercles have a much larger, flat mamelon, which is about two-thirds instead of one-third the diameter of the boss. It also resembles a small Persian Miocene *Psammechinus affinis*, Fuchs,[4] in which the scrobicular circles are complete on each plate, so that the adjacent scrobicular areas are separated by two lines of granules instead of by only one.

Oligophyma cellensis, Pomel,[5] is another ally, but that has a much smaller peristome and longer, lower interambulacral plates.

Genus COPTOSOMA, Desor, 1858.

1. COPTOSOMA THEVESTENSE, Per. & G.

Cyphosoma Thevestense, Peron & Gauthier, 1879: "Ech. foss. Algér.," fasc. vi, p. 105, pl. xiii, figs. 5–8.

DISTRIBUTION.—Turonian: Tebessa, near Constantine, Algeria. Turonian (?): Abu Roasch, Egypt; Coll. Geol. Surv. Egypt, No. 50.

[1] Pomel, "Pal. Algér.," Zooph., fasc. 2, Ech., livr. 1 (1885), pl. C, xii, figs. 1–4.
[2] Ibid., pl. C, xii, figs. 5–8.
[3] Ibid., pl. C, xi, figs. 5–8.
[4] Fuchs, "Tert. Ech. Persien": Sitz. Ak. Wiss. Wien, vol. lxxxi, pt. 1 (1880), p. 99, pl., figs. 6–16.
[5] Pomel, op. cit., pl. C, x, figs. 1–7.

Remarks.—This species is represented by three specimens. The pores are in arcs of five to six pairs in each compound ambulacral plate. The specimens agree with the Algerian type in all important respects. The ambulacral plates are unituberculate, and each tubercle is surrounded by a complete scrobicular circle, so that the scrobicular areas are not confluent. The tuberculation of an Egyptian specimen is shown on Pl. V, Fig. 2.

Genus LAGANUM, Gray, 1825.

1. Laganum depressum, Less.

Synonymy.—See A. Agassiz, "Revision of Echini," pt. i, 1872, p. 138.

Distribution. — Recent: Pacific and Indian Oceans, Red Sea, Persian Gulf. Pleistocene: E. Africa; Suez; Coll. Geol. Surv. Egypt, No. 968.

Remarks.—The collection includes six specimens of a *Laganum* from the Pleistocene of the Suez Canal (Coll. Geol. Surv. Egypt, No. 968). The specimens appear at first sight to differ from the typical *L. depressum*, as the margins are tumid, and there is a depression around the test between the apex and the margin. This character is described by Professor A. Agassiz in *L. Bonani*,[1] whereas the test of *L. depressum* is said[2] to have thin margins. The shape of the petals in one or two specimens is also different from the typical *L. depressum*, as the petals are more pointed at their outer ends. Examination, however, of the large series of *L. depressum* in the Zoological Department shows that these characters vary so much in this species that the Egyptian fossils may be safely referred to it. Some specimens registered as 58. 5. 15. 154, have equally pointed petals; others from the Kingsmill Islands have the petals pointed at the ends, but the poriferous zones are broader; while in some other specimens the pore-zones are as narrow as in the fossil specimens from Suez. Among the many varieties of *L. depressum* these specimens are most nearly allied to *Laganum attenuatum*, L. Ag.,[3] with which they agree in the circular actinal depression and the general shape of the test. Some of the six specimens have the external shape of the variety *L. ellipticum*, L. Ag.,[4] and others have the more strongly pentagonal shape of the typical *L. depressum*.[5]

L. attenuatum is a variety most typical of the Red Sea and Persian Gulf.

Genus SCUTELLA, Lam., 1816.

1. Scutella subrotunda var. Paulensis, L. Ag.,[6] 1841.

Remarks.—This echinid is represented in the collection by two Miocene specimens (No. 995), of which one is broken. The

[1] A. Agassiz, Revision Echini, pt. iii (1873), p. 517.
[2] Ibid., p. 518.
[3] L. Agassiz and Desor, "Cat. Raiss.": Ann. Sci. nat., vol. vii (1847), p. 132.
[4] L. Agassiz, Mon. Scut., p. 111, pl. xxiii, figs. 13, 14.
[5] Cf. ibid., pl. xxiii, figs. 1–3.
[6] *Scutella Paulensis*, L. Agassiz, Monogr. Scutelles, 1841, p. 83, pl. xix, figs. 8–10.

echinids agree with *S. subrotunda* (*non* Leske) in the length of the petals, whereby they differ from the Tongrian *S. striatula*, Marc. de Serr. They differ from the typical *S. subrotunda*, Leske, by the absence of the notch in the posterior margin of the test behind the anus. In this character they agree with *S. Paulensis*, L. Ag.; but they differ from L. Agassiz's type of that form by their greater equality of length and breadth. Agassiz remarked the close resemblance of *S. Paulensis* and *S. subrotunda*; and it seems to me, as the shape is inconstant, that the former species should be reduced to a variety of the latter, characterized by the absence of the notch and by the less branched actinal furrows. The branching of the furrows is, however, inconstant; they are not well marked in the specimens; but in some areas the furrows branch once as in *S. Paulensis*, whereas in other areas there are distinct secondary branches as well.

The original locality of *S. Paulensis* is St. Paul-trois-Chateaux, near Dax, and its horizon is Lower Miocene or Langhian.[1]

Fuchs has described two Egyptian Miocene *Scutellæ*. In *S. rostrata*, Fuchs,[2] from Siuah, the posterior margin is curved and not truncate; and the interporiferous areas of the petals is broader than in the two echinids of the Egyptian Survey collection. The general shape of these specimens agrees with that of *S. ammonis*, Fuchs,[3] in which the petals are a little shorter; thus, the length of the anterior petal is $\frac{8}{15}$ of the distance from the inner end of the petal to the anterior margin of the test, whereas the same proportion in these specimens is $\frac{2}{3}$.

Genus CONOCLYPEUS, L. Agassiz, 1839.

1. Conoclypeus Delanouei, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 82, pl. ii, fig. 17.

Var. milviformis,[4] nov.

Distribution. — Libyan Series: Coll. Geol. Surv. Egypt, *ex* No. 858. Pl. VI, Fig. 2; two-thirds natural size.

Remarks.—Five specimens in the collection agree in all essential respects with De Loriol-le-Fort's *C. Delanouei*, except that the shape is not elliptical but somewhat kite-shaped. The greatest width is a trifle anterior to the peristome; the sides thence run straight backward, converging slightly till opposite the anterior margin of the periproct; thence they bend sharply round to the well-curved posterior extremity. As De Loriol's figure (17*a*) is not regularly elliptical, and as the test shows a tendency towards this kite-shaped base, it seems unnecessary to make a new species for these echinids. But the difference is so constant in the five specimens that it is desirable to notice it as a varietal character.

[1] e.g. Depéret, "Classification et parallelisme du Système Miocène": Bull. Soc. géol. France, ser. 3, vol. xxi (1893), p. 176.

[2] Fuchs, Beitr. libysch. Wüste, vol. i (1883), p. 48, pl. xvii, figs. 4–6.

[3] Fuchs, ibid., p. 48, pl. xiv, figs. 1–4.

[4] From *milvus*, 'a kite,' the test being kite-shaped.

Genus RHYNCHOPYGUS, D'Orbigny, 1855.

1. Rhynchopygus Zitteli, De Loriol, 1883.

"Beitr. libysch. Wüste," vol. ii, pt. 1, p. 18, pl. ii, figs. 9–11.

Distribution. — Mokattam Series: Minieh (De Loriol-le-Fort); Coll. Geol. Surv. Egypt, *ex* Nos. 862, 863.

Remarks.—The echinid referred to this species differs from the type only by being slightly broader in proportion to its width.

Genus ECHINOLAMPAS, Gray, 1825.

1. Echinolampas tumidopetalum, n.sp.

Diagnosis.

Test large and tall, subconical, rising from a level base. Seen from above the shape is sub-elliptical, but the posterior half is broader and fuller than the anterior part.

Apical area and mouth subcentral.

Ambulacra.—The petaloid portions are very swollen and upraised. The inequality in the length of the poriferous zones of the antero-lateral pair of petals is considerable. The petals are long, reaching nearly to the margins. The poriferous zones are narrow; the inter-poriferous area is long, lanceolate.

Floscelle well developed; the bourrelets large and conspicuous.

Dimensions.

	mm.	Crushed specimen. mm.
Height	48	... 49
Length	78	... 79
Breadth	65	... 56
Length of petal of antero-lateral ambulacrum	38	... 35
Width of petal of antero-lateral ambulacrum	11	... 10·5
Width of poriferous zone of ditto	2	... 2
Width of interporiferous zone of ditto ...	7	... 6·5
Distance of apex from anterior margin ...	38	... 35
Distance of mouth from anterior margin ...	35	

Distribution.—Miocene: Coll. Geol. Surv. Egypt, Nos. 966, 972.

Figures.—Pl. VI, Fig. 1*a*, a specimen from above; Fig. 1*b*, the same specimen from the side: nat. size.

Affinities.—This species is represented in the collection by four specimens, of which three are somewhat broken, while the fourth is a little deformed by lateral pressure. The most striking character of the species is its swollen ambulacra, which are of the type met with in *Echinolampas stellifera*, from the Calcaire Grossier. From this species *E. tumidopetalum* differs by its greater size and more conical test.

Among known species of *Echinolampas* this most nearly resembles *E. Anguillæ*, Cott.,[1] from which it differs by the tumid petals and by the more conical form of the test. The outline seen from above or below is almost identical with Cotteau's figures 7 and 8 of his West Indian species. *Echinolampas florescens*, Pom., var. *coarctata*,[2]

[1] G. Cotteau, "Descr. Ech. tert. St. Barth. et Anguilla": Handl. k. Svens. Vet. Akad., vol. xiii, No. 9 (1875), p. 24, pl. iv, figs. 5–8.

[2] A. Pomel, "Ech. Kef. Ighoud": Mat. Carte géol. Algérie, ser. i, Pal. (1885), p. 26, pl. iii, figs. 12–14.

has a high test of much the same form as *E. tumidopetalum*; but the petals are much broader, shorter, and more leaf-like, and the floscelle less conspicuous.

2. Echinolampas globulus, Laube, 1869.

"Ech. vicent. Tert. Geb.": Denk. Ak. Wiss. Wien, vol. xxix, pt. 2 (1869), p. 24, pl. iv, fig. 5.

Distribution.—Lower Eocene—Libyan Series: near Assiut, Egypt (De Loriol-le-Fort); Coll. Geol. Surv. Egypt, No 631.

Ten specimens of this variable species from the Lower Eocene near Assiut.

3. Echinolampas amygdala, Desor, 1847.

Agassiz & Desor, "Cat. Raiss.": Ann. Sci. nat., Zool., ser. 3, vol. vii, p. 164.

There is one echinid in the collection (*ex* Nos. 862–3) the proportions of which agree with those of the Egyptian specimen, which, according to De Loriol, is the typical form of this species. The species was based by Desor on an Egyptian fossil. The dimensions are as follow :—

	Coll. Geol. Surv. Egypt.	De Loriol-le-Fort.
Length	42 mm.	... 30–38 mm.
Breadth	20 mm.	... —
Ratio of breadth to length ...	·48	... ·50
Height	32 mm.	... —
Ratio of height to length ...	·76	... ·74

Distribution.—Mokattam Series: Mokattam (De Loriol-le-Fort). Libyan Series: Coll. Geol. Surv. Egypt, *ex* Nos. 862–3.

4. Echinolampas Perrieri, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 95, pl. v, fig. 2.

Distribution.—Mokattam Series: Mokattam, Thebes (De Loriol-le-Fort); Coll. Geol. Surv. Egypt, *ex* No. 859.

The collection includes a small specimen from the Mokattam Series, which appears to be referable to *E. Perrieri*, Lor., though that species was described from the Upper Eocene beds of the Siuah Oasis. M. de Loriol-le-Fort did, however, record a doubtful specimen from the Mokattam beds of the Beharieh Oasis.

The dimensions are as follow :—

	De Loriol.	Egypt. Geol. Surv., *ex* No. 859.
Length	52–62 mm.	... 46 mm.
Breadth	— ...	... 38 mm.
Ratio of breadth to length ...	·82 ...	... ·83
Height	— ...	... 20·5 mm.
Ratio of height to length ...	·42–·45 ...	... ·44

5. Echinolampas Libycus, De Loriol, 1883.

"Beitr. libysch. Wüste," vol. ii, pt. 1, p. 31, pl. v, figs. 1–3.

Distribution.—Mokattam Series: Siuah (De Loriol-le-Fort); Coll. Geol. Surv. Egypt, one specimen *ex* No. 859.

No. 859 in the Egyptian Survey Collection includes two specimens which are clearly specifically distinct. The larger specimen has the

following dimensions, which are those of *E. Libycus* and *E. subcylindricus*, Des. But the characters of the petals show that the Egyptian Survey specimen is nearer to the former. The specimen is broken at the posterior end, so the specific determination is somewhat uncertain.

DIMENSIONS.

Length	70 mm.
Breadth	55 mm.
Ratio of breadth to length	·786
Height	35 mm.
Ratio of height to length	·50

6. ECHINOLAMPAS AMPLUS, Fuchs, 1883.

"Beitr. Kenntn. Miocaenfauna Aegypt." : Beitr. Geol. Pal. Lib. Wüste, vol. i, p. 45, pl. xiv, figs. 5–8.

DISTRIBUTION. — Miocene : Siuah and Geneffe (Fuchs) ; Coll. Geol. Surv. Egypt, No. 643 ; near Wady Jiaffra, between Cairo and Suez, Camp No. 9.

Genus EUPATAGUS, L. Agassiz, 1847.

1. EUPATAGUS COTTEAUI, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 139, pl. xi, figs. 8–10.

DISTRIBUTION.—Libyan Series : near Thebes (De Loriol-le-Fort) ; Coll. Geol. Surv. Egypt, *ex* Nos. 861 and 867.

2. EUPATAGUS LIBYCUS, De Loriol, 1883.

"Beitr. libysch. Wüste," vol. ii, pt. 1, p. 52, pl. xi, fig. 4.

DISTRIBUTION. — Libyan Series : El Guss Abu Said, west of Farafrah (De Loriol-le-Fort) ; Coll. Geol. Surv. Egypt, three specimens *ex* No. 868.

Genus HYPSOPATAGUS, Pomel, 1883.

1. ? HYPSOPATAGUS LEFEBVREI (De Loriol), 1881.

Macropneustes Lefebvrei, De Loriol, 1881 : Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 131, pl. ix, figs. 7–9.

Hypsospatangus Lefebvrei, Cotteau, 1886 : Pal. franç. Terr. tert., vol. i, Eoc. Ech., p. 96.

DISTRIBUTION.— Libyan Series : near Assiut, Minieh, and El Guss Abu Said, west of Farafrah (De Loriol-le-Fort) ; ? Assiut ; Coll. Geol. Surv. Egypt, *ex* No. 631.

The only specimen that may belong to this species is one that is so much broken at the hinder end that it is not possible to determine whether a fasciole was present. The shape of the petals is, however, nearer to that of *Hypsopatagus* than to *Eupatagus*.

2. HYPSOPATAGUS, sp.

Libyan Series : Coll. Geol. Surv. Egypt, *ex* Nos. 862–3, 867.

There are two echinids in the collection which are elongate forms of *Hypsopatagus*, but they are too ill-preserved for description. The outline of one is shown on Pl. VI, Fig. 4, which presents

a considerable resemblance to the *Eupatagus Siokutensis*, Fuchs,[1] which has, however, a more cordate or elliptical test.

Genus HEMIASTER, Desor, 1847.

1. Hemiaster Schweinfurthi, De Loriol, 1883.

"Beitr. libysch. Wüste," vol. ii, pt. 1, p. 34, pl. viii, figs. 3–5.

Distribution. — Libyan Series: El Guss Abu Said, west of Farafrah (De Loriol-le-Fort); Coll. Geol. Surv. Egypt, *ex* Nos. 862–3.

PERICOSMUS, L. Ag., 1847.

1. Pericosmus latus, Ag. & Des., 1847.

Agassiz & Desor., op. cit., p. 19, pl. vi, figs. xvi, 1.

Remarks.—This well-known echinid is represented in the collection by two specimens from the Miocene (Geol. Surv. Coll. Egypt, No. 964). They agree with Agassiz's cast (M 23), but differ slightly from Agassiz & Desor's figure by the fact that posteriorly the test slightly overhangs the periproct, which cannot be seen from above. The specimens agree with Cotteau's admirable description of the species;[2] and the posterior extremity of the test agrees with his figure of *P. Orbignyi*, Cott., to which he applies the same description as to *P. latus*. Hence the Egyptian form agrees with Cotteau's description better than with the original figure. The echinids differ from *P. Orbignyi*, Cott., by the greater equality of length and breadth, the dimensions being 75 mm. and 76 mm. respectively.

2. Pericosmus Peroni, Cott.

G. Cotteau, "Faune terr. tert. Corse": Ann. Soc. Agric. Lyons, ser. 4, vol. ix, 1877, p. 314, pl. xiv, figs. 3, 4.

Distribution. — Helvetian: Corsica; Egypt; Coll. Geol. Surv. Egypt, No. 659.

The collection contains three broken *Pericosmi*, which have the anterior apex, steep anterior slope, and long posterior slope characteristic of *P. Peroni*, Cott. Two of the three echinids are too broken for satisfactory determination, but a third shows the form of *P. Peroni* fairly well.

Genus LINTHIA, Merian, 1853.

1. Linthia Aschersoni, De Loriol, 1883.

"Beitr. libysch. Wüste," vol. ii, pt. 1, p. 37, pl. ix, figs. 1–4.

Distribution.—Libyan Series: Gebel Ter, near Esneh, and west of Farafrah (De Loriol-le-Fort); Coll. Geol. Surv. Egypt, *ex* Nos. 862–3.

2. Linthia Esnehensis—Aschersoni.

Linthia Esnehensis, De Loriol, 1883: "Beitr. libysch. Wüste," vol. ii, pt. 1, p. 39, pl. ix, figs. 5, 6.

L. Aschersoni, De Loriol, 1883: ibid., p. 37, pl. ix, figs. 1–4.

[1] Fuchs, "Tert. Ech. Persien": Sitz. Ak. Wiss. Wien, vol. lxxxi, pt. 1 (1880), p. 100, pl., figs. 17–20.

[2] G. Cotteau, "Faune terr. tert. Corse": Ann. Soc. Agric. Lyons, ser. 4, vol. ix, pp. 310–12.

There is in the collection a specimen which is intermediate between the above, but nearer, if anything, to *L. Esnehensis*. The relative dimensions are as follows:—

	Esnehensis.	*Aschersoni*.	Egypt. Surv. Coll.
Length	30–42 mm.	26–37 mm.	36 mm.
Ratio of breadth to length	1 – 1·10 ...	1 ...	1·02
Ratio of height to length	·73 – ·80 ...	·65 – ·67 ...	·74

But the Egyptian Survey specimen has the shallow anteal notch and broader anterior ambulacrum of *L. Aschersoni*; the ridge of the posterior interradius is higher than in *L. Aschersoni*, but lower than in *L. Esnehensis*. The apical disc of this echinid is shown on Pl. VI, Fig. 3.

Distribution.—*L. Esnehensis*, Lor., Libyan at Gebel Ter, near Esneh (De Loriol-le-Fort). *L. Aschersoni*, Lor., Libyan at Gebel Ter, near Esneh, and west of Farafrah.

The above-mentioned Egyptian fossil is from the Libyan Series (De Loriol-le-Fort), *ex* Nos. 864–5.

3. Linthia cavernosa, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 111, pl. viii, figs. 8–10.

Distribution.—Libyan Series: Gebel Omm-el-Renneiem; El Aouhi, near Edfou; Djebel Fatira (De Loriol-le-Fort); Coll. Geol. Surv. Egypt, *ex* No. 867.

4. Linthia Delanouei, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 109, pl. vii, fig. 12.

Distribution.—Mokattam Series: Mokattam (De Loriol-le-Fort). Libyan Series: Gebel Ter, near Esneh (De Loriol-le-Fort); Coll. Geol. Surv. Egypt, *ex* No. 996.

The collection includes one large, well-preserved specimen of this species. Its dimensions are:

	mm.
Length	60
Breadth	57·5
Height	45
Distance of apical system from anterior margin	25

5. Linthia (?) Cotteaui, Tournouer, 1870.

Synonymy.

Periaster Cotteaui, Tournouer, 1870, "Éch. calc. à aster. sud-ouest France": Actes Soc. linn. Bord., vol. xxvii, p. 33, pl. xvii, fig. 5.

Linthia Cotteaui, Cotteau, 1886: "Pal. franç. Terr. tert.," vol. i, Ech., p. 241, pl. lxxv.

Distribution.—Mid. Eocene: Hastingues, Landes (Tournouer & Cotteau). Libyan Series: Egypt; Coll. Geol. Surv. Egypt, *ex* No. 868.

Remarks.—The generic position of this species seems to me doubtful. The dimensions of the specimen assigned to it are as follow:—

Length	37 mm.
Breadth	35 mm.
Ratio of breadth to length	·95
Height	27·5 mm.
Ratio of height to length	·74
Apical disc: distance from anterior margin	17 mm.
Apical disc: ratio of distance from anterior margin to length	·46

The specimen shows both peripetalous and lateral fascioles. The dimensions show that the apical disc is anterior in position, and hence the fossil is a *Linthia*. The echinid has, however, the very short posterior ambulacral petals, while the petals of the anterior pair are longer and more flexuous. The petals, moreover, are deep. These characters are unusual in *Linthia*, but are very frequent in *Schizaster*. Hence the species has more the characters of a *Schizaster* with an anterior apical disc than of a normal *Linthia*. Cotteau, indeed, remarks (op. cit., p. 243) that the French specimens have the apical disc either central or even slightly posterior; so that he was doubtful as to the generic position of the species.

The nearest allied echinid previously recorded from Egypt is the *Linthia Arizensis* (D'Arch.), which is, however, much flatter and more depressed.

As there is only one specimen of this form, its specific determination is necessarily somewhat uncertain.

Genus SCHIZASTER, L. Agassiz, 1847.

1. Schizaster Thebensis, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 125, pl. ix, figs. 5–6.

Distribution. — Libyan Series: Todtenberg, near Assiut (De Loriol-le-Fort); Coll. Geol. Surv. Egypt, *ex* No. 868.

2. Schizaster Mokattamensis, De Loriol, 1883.

"Beitr. libysch. Wüste," vol. ii, pt. 1, p. 41, pl. x, figs. 1, 2.

Distribution. — Mokattam Series: Mokattam (De Loriol-le-Fort). Libyan Series: Gebel Ter, near Esneh (De Loriol-le-Fort); Geol. Surv. Egypt, *ex* No. 867.

3. Schizaster Zitteli, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 122, pl. ix, fig. 2.

There are one good and three crushed specimens of this species in Nos. 864–5.

Distribution.—Mokattam Series: Mokattam (De Loriol-le-Fort). Libyan Series: Coll. Geol. Surv. Egypt, *ex* Nos. 864–5; Gebel Ter, near Esneh (De Loriol-le-Fort).

4. Schizaster Gaudryi, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 120, pl. ix, fig. 1.

Distribution.—Mokattam Series: near Thebes; Mokattam (De Loriol-le-Fort). Libyan Series: Coll. Geol. Surv. Egypt, No. 996.

The collection includes two specimens of this species. The two specimens differ in the size of the anterior ambulacral depression;

in one of them the ambulacral furrow is considerably larger than in the other. It seems unnecessary to regard this as a specific or varietal difference, for it may be either sexual or a seasonal variation, the anterior furrow being enlarged to serve as a marsupium.

EXPLANATION OF PLATE V.

FIGS. 1*a* and 1*b*. *Rhabdocidaris Libyensis*, nov. sp., from the side and from above; nat. size. Fig. 1*c*, ambital interambulacral plates of the same, × 2 diam. Fig. 1*d*, ambital ambulacral plates of the same, × 4 diam.

FIG. 2. *Coptosoma Thevestense*, Per. & G., ambital plates, × 4 diam. Turonian: Abu Rousch.

FIG. 3. *Psammechinus Duciei*, Wright, ambital plates of Egyptian specimen, × 5 diam.

FIGS. 4 and 5. *Psammechinus Lyonsi*, nov. sp. Fig. 4*a*, side view, × 2 diam.; Fig. 4*b*, actinal view, × 2 diam.; Fig. 4*c*, ambital plates, × 8 diam. FIG. 5. Ambital interambulacral plates of another specimen, × 8 diam.

EXPLANATION OF PLATE VI.

FIGS. 1*a* and 1*b*. *Echinolampas tumidopetalum*, nov. sp., abactinal and lateral views; nat. size.

FIG. 2. *Conoclypeus Delanouei*, Lor., var. *milviformis*, nov., actinal surface; two-thirds nat. size.

FIG. 3. *Linthia Esnehensis—Aschersoni*, apical disc, × 5 diam.

FIG. 4. *Hypsopatagus*, sp., side view; nat. size.

III.—The Origin of the Vale of Marshwood in West Dorset.[1]

By A. J. Jukes-Browne, B.A., F.G.S.

THE great sheet of Chalk which, with the subjacent Greensand and Gault, stretches through so large a part of Southern England and underlies the whole of the Hampshire Basin, terminates abruptly in West Dorset. There is no doubt that the Upper Cretaceous rocks once spread continuously over the Jurassic hills east of Bridport and across the Vale of Marshwood, and were united to the corresponding beds in East Devon, where the Chalk and Greensand are so conspicuous in the cliffs near Beer Head.

To those who are unacquainted with geological methods this statement may seem highly imaginative, since, at the present time, there is a broad intervening tract, from the centre of which all traces of Cretaceous strata have been removed, and around which only a few isolated patches or outliers of Greensand remain as relics of their former extension; yet to the eye of a geologist these very outliers, of which Pilsdon Pen is one, are clear and certain proofs that a continuous sheet of the same material once overspread the whole area.

The physical features of this area may be briefly described, as they are not likely to be familiar to those who do not live in the west of Dorset. The Vale of Marshwood is an area of low ground, most of which lies between 100 and 200 feet above the sea; its length is about five miles and its breadth three; its floor consists of the clays of the Lower and Middle Lias, and it is encircled by steep

[1] This paper is reprinted, with some alterations, from the Proceedings of the Dorset Nat. Hist. and Ant. Field Club, vol. xviii, and is published with the permission of the Director-General of the Geological Survey of Great Britain.

slopes formed by the yellow micaceous sands of the Marlstone Beds, the cincture of the hills being only broken on the south by the gaps through which the rivers Char and Simene escape to the sea and by a dry gap or pass above Chideock.

The hills on the north side of the Vale are higher than those on the south side, and they form the watershed dividing the valley of the Axe from the valley of the Char, which occupies the greater part of Marshwood Vale. Pilsdon Pen and Lewesdon Hill are the highest hills in Dorset, Pilsdon being 907 feet and Lewesdon 894 feet, according to the latest Ordnance Survey Map. It is only on the Blackdown Hills in Devon that the Upper Greensand reaches a greater height than this, and these hills, although so much farther west, do not attain to more than 930 feet.

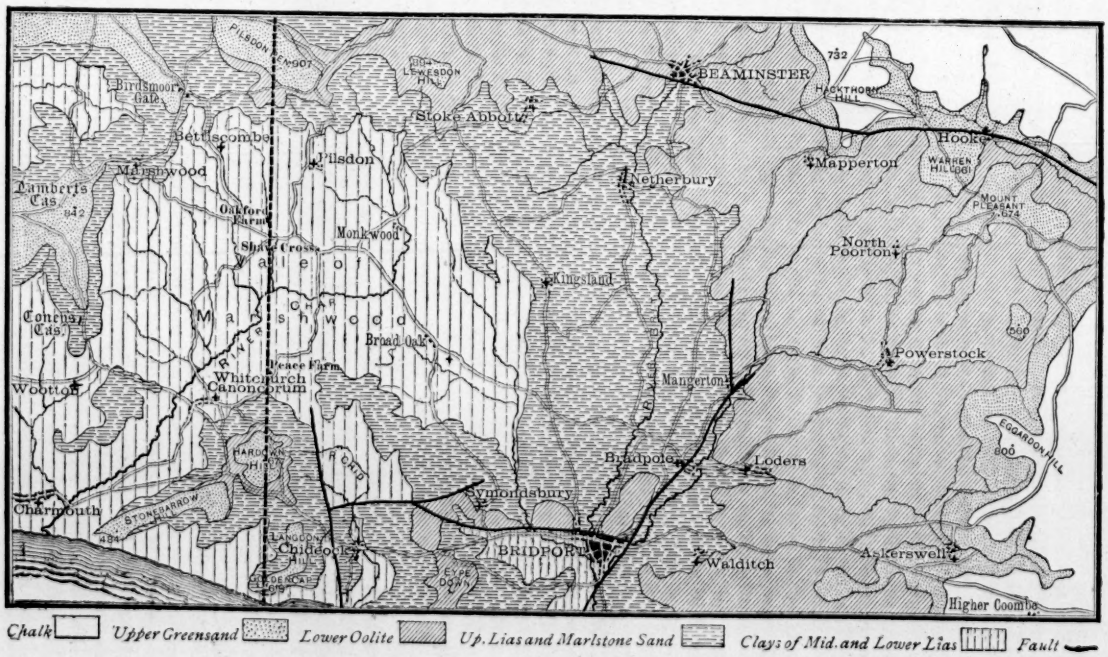
It is obvious, therefore, that there must be some local reason for the great height to which the Greensand reaches in Dorset, and yet I am not aware that any geologist has accounted for the fact.

It may seem a paradox to say that the height of the Greensand hills and great hollow of the Vale of Marshwood are due to one and the same cause, yet it is true that they are so closely related to one another that the history of the one involves the history of the other. This history begins with the uplift of the strata which took place in Miocene or Pliocene times, and bent the beds into a dome-shaped elevation, or *pericline*, i.e., an area in which the strata are bent up so as to dip outwards in all directions from a central spot or axis.

I propose to ascertain the probable whereabouts of this centre by a consideration of the levels through which the base of the Upper Greensand passes in East Devon and West Dorset. It might be thought that this spot could be found more easily by examining the arrangement of the Jurassic rocks on the borders of the Vale of Marshwood, but though these undoubtedly show the existence of an anticlinal axis running in an east-and-west direction from which the strata slope to north and south, the curve to east and west is not so apparent in them because they had received a decided easterly tilt before the Greensand was deposited on them. Moreover, the Jurassic rocks are broken by many faults, and only a few of these affect the Cretaceous strata, for most of them seem to date from the Purbeck and Wealden periods, when the above-mentioned tilting was produced.

It is therefore by the position and relative heights attained by the base-line of the Gault and Greensand that the periclinal uplift of this district can best be determined, and by transferring the boundary-lines from the published Geological Survey map to the six-inch county maps, we can easily trace the rise and fall of this base-line. The boundary-lines on the old Geological Survey map are not everywhere correct, but I have good reason to believe that this particular boundary is sufficiently accurate for our purpose. The map (Fig. 1) is based on the new one-inch Ordnance map, and the geological lines have been partially revised, so that it is more accurate than the old Geological Survey map.

FIG. 1.—GEOLOGICAL MAP OF A PORTION OF WEST DORSET.
Scale half an inch to a mile.



Commencing with a traverse from west to east through Pilsdon and Lewesdon, and starting the base-line of the Greensand at Secktor, near Axminster, we find it there to be only about 320 feet above sea-level, and thence it rises gradually eastward till it reaches 580 feet at Birdsmoor Gate, 700 feet at the southern end of Pilsdon, and about 770 feet on Lewesdon. Between Lewesdon and Beaminster there are several faults breaking the Jurassic rocks, but it is not certain that any of them displace the Cretaceous series, and on Hackthorn Hill the base of the Greensand is close to the 500 feet contour. The distance from Lewesdon to this point is four miles, and, assuming the fall to be gradual, it is a little, but not much more, rapid than the rise from the west up to Lewesdon.

Taking next a traverse through the southern outliers near the coast, we find the Cretaceous base-line in Black Ven Cliff at about 320 feet above the sea. Thence it rises to about 350 feet in Stone Barrow, and 400 and more on Golden Cap and Langdon Hill, and finally to about 500 feet on Eype Down. Then comes a space of four miles occupied by low ground near Bridport, and when Greensand is next found on Shipton Hill, its base has fallen to 400 feet, sinking still lower eastward to 300 feet at Askerswell. Along this line of country, then, as along the first, we seem to have a gradual rise and fall in the height of the Cretaceous base-line.

We will next trace the rise and fall of the same line from north to south. This is best shown on the western side of the area. North of Thorncombe village the base of the Greensand lies at about 450 feet, on the south side of that outlier in the same latitude it is nearly 500, by Lambert's Castle it is about 600 feet; thence it falls to 550 feet below Coney's Castle and to 350 feet at Stonebarrow, $2\frac{1}{2}$ miles further south.

On the eastern side of the district the regularity of the rise is broken by faults, but we find it rising to a maximum of 600 feet on Drakenorth Hill, east of Poorton, falling thence rapidly both to the north and to the south. Even where it is faulted up again on Eggardon Hill it does not seem to get much above 400 feet, and at Combe, near Litton Cheney, it is down to about 300 feet.

We may fairly assume that the centre of the uplift, or pericline, will be found by drawing lines between the points where the base-line reaches its greatest height, namely, from Lambert's Castle to Drakenorth Hill, and from Lewesdon to Eype Down. The intersection of these lines occurs a little east of Monkswood, above the low ridge which forms the watershed between the Char and the head branch of the Simene brook. We may take this spot as the approximate centre of the pericline, which appears to have an elliptical shape, its longest axis being from east to west and its shortest from north to south. We can even form a good estimate of the height to which the base of the Greensand reached over this centre by prolonging the actual rise of the base-line in the Pilsdon outlier, for at the north end of Blackdown, by Stony Knap, it is at 500 feet, rising thence to 700 feet below the Pen, and if this rise were continued south-eastward to the spot above mentioned it would

bring the base to a height of 877 feet. Assuming the thickness of the Greensand there to have been 180 feet, the Chalk would have come in at about 1,150 feet.

The relative levels of sea and land varied, of course, at different epochs of Tertiary time, but we are quite warranted in believing that there was a time when the Chalk and Greensand formed a continuous mantle over the rocks which now occur in West Dorset. Let us next consider how this mantle of Cretaceous material has been so largely removed from the district in question.

When the country was raised above the level of the sea at the close of the Oligocene period it must have undergone considerable erosion from the planing action of the sea waves, and if the flexures were commenced at that time the anticlines would suffer most. We know very little about the history of this part of England during the Miocene and Pliocene times, but the final result of the successive upheavals and denudations was to leave a surface of erosion which was planed across the flexures, and both upheaval and denudation had been carried on to such an extent that the Chalk had been either entirely or almost entirely removed from the central parts of the anticlinal areas.

This surface of erosion was what our American cousins call a *peneplain*, that is to say, it was not a level plain or plateau, but had its slight irregularities and slopes, and had, moreover, a summit elevation from which it sloped in more than one direction. A consideration of the present watersheds and of the river-courses in Dorset and the adjacent counties leads us to infer that the original watershed of this peneplain lay to the north and west of the line now occupied by the Chalk escarpment.[1] It probably trended from somewhere in the neighbourhood of Wincanton at a high level above Sherborne and Yetminster to Beaminster Down, and thence over Lewesdon and Pilsdon to the hills between Axminster and Lyme. The western part of this line, from Beaminster Down along the ridge on which Lewesdon and Pilsdon stand, is still the watershed between the streams which run southward and those which drain into the rivers Parret and Axe.

It will be noticed that this watershed does not coincide with the longer axis of the Marshwood pericline, but lies to the north of it. In order, therefore, to understand the drainage system of this part of Dorset we must imagine a time when the surface of the land sloped gently both northward and southward from the line above-mentioned. On this surface there was a certain accumulation of clay, pebbles, cherts, and flints, the heavy and insoluble relics of the Eocene, Greensand, and Chalk which had been destroyed; remnants of this deposit, which is generally called "the clay with flints," still remain on the tops of the higher hills.

The rain flowing down the southern slope of this surface gathered into streams, which cut channels for themselves through the Chalk

[1] See "Origin of the Valleys of North Dorset," in Proc. Dorset N.H. and A.F. Club, vol. xvi, p. 5.

and Greensand. They ran, of course, high above the present surface, and their courses were prolonged far to the southward before reaching the sea; indeed, during the Miocene and again in the later Pliocene time it is probable that most of the English Channel was dry land, and that these Dorset streams were merely tributaries of a large river which ran westward down the valley of the Channel.

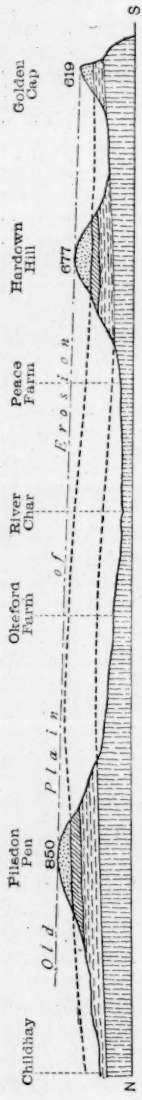


FIG. 2.—Section across the Vale of Marshwood along the broken line on the Map.

Now the slope along which these streams made their way was planed across the summit of the low dome or pericline, which has been described; and as we have calculated the base of the Greensand on this summit to have been about 100 feet higher than it is at Lewesdon, where the thickness of Greensand at present is not more than 130 feet, and as the surface sloped southwards from Lewesdon, there cannot have been much Greensand left over the central area of the pericline when the streams began to make their valleys. Hence, as they deepened their channels they would quickly cut through the Greensand on the central area and would soon enter the Jurassic beds on which the sand rests; these beds are the Midford Sand, the Upper Lias clay (which is thin), and the Marlstone Sands.

As soon as any stream cut into the Upper Lias the water on the overlying sands would issue in the form of springs. Thereby the volume of the streams would be increased and at the same time landslips would take place, as is always the case where springs issue from sand overlying a clay. The valleys would be rapidly widened, and during periods of upheaval they would be deepened also. Much of this work was probably done during the Glacial Period, and was finally completed during the time when the raised beaches of the South Coast were being elevated to their present height. Over the western part of the pericline the Midford Sands and Upper Lias are absent; that is to say, they were planed off before the Greensand was deposited, and the latter rests directly on the Marlstone Sands. Here the process of valley erosion would continue till the base of these sands was reached, when strong springs would be thrown out by the underlying *margaritatus* clays, and these clays would be for a certain distance exposed along the valley bottoms.

We must remember that all this time the slope of the valley-ways was less than the southerly inclination of the beds on the southern curve of the pericline; hence the rivers, after cutting

through the lower clays for a space, would again enter the Marlstone Sand and still further south would again enter the Upper Lias and Midford Sand, as shown in the diagram (Fig. 2).

Now, where the sides of a valley consist of clay, they are rapidly acted on by rain and frost and are made to recede by frequent landslips, but where they consist of firm and dry sand there is very little slipping and the valleys remain comparatively narrow. Thus it came to pass that a wide tract of clay was gradually exposed over the western part of the periclinal area, while to the southward the rivers pass through valleys with steep slopes on each side, the intervening tracts rising into a succession of hills, some of which are capped by patches of Inferior Oolite and others by remnants of the original covering of Greensand.

These southern hills are well seen by anyone standing at the foot of Pilsdon Pen, and they look as if they would present an impassable barrier to any river running southward from the watershed on which the observer stands.

The rivers which now drain the district are the Char and the Simene, while the Brit drains the eastern part of the periclinal area, and they all make their way through gaps in the southern hills. But, besides the valleys of these rivers, there is a wide gap at the head of the valley of the little river Chid, which runs through Chideock, and I think it probable that this gap was part of the valley of a river which had a more northern source. There is little doubt that in some cases one river-system extended itself at the expense of another, the lateral tributaries of the one encroaching on the area drained by the other, and sometimes entirely cutting off or capturing the headwaters of the adjacent river.[1]

The present course of the Char is so different from the comparatively straight courses of the Simene and the Brit, that it suggests the idea of its having absorbed the tributaries of an eastern neighbour. The col at the present head of the Chideock valley does not rise above 250 feet, the hills on each side being double that height, and I am inclined to think that there was a time, before the valleys were carved out to their present depth, when three rivers traversed the Vale of Marshwood, and that the ancestor of the Chid was one of them. The final sculpturing of the country took place during and soon after the close of the Glacial Period, and it was probably then that the capture by the Char of the upper tributaries of the Chid was accomplished.

In conclusion, I may briefly call attention to the points of resemblance and difference between the Vale of Marshwood and the Weald of South-Eastern England. Both are elliptical periclinal areas, both have been truncated by planes of (presumably marine) erosion, and both have rivers, which, after traversing the inner plain, pass through gaps in the southern escarpment to reach the sea. In the Weald, however, the watershed coincides roughly with the longer

[1] For a case in Lincolnshire described by the author, see Quart. Journ. Geol. Soc., vol. xxxix, p. 596, 1883.

axis of the pericline, and the streams run both northward and southward, so that both lines of escarpment are trenched by river-valleys. In the case of the Dorsetshire Weald the original watershed was outside and north of the central axis, so that all the streams ran southward and only the southern border is trenched by river-valleys.

In both areas, too, the denudation of the central region has laid bare a large tract of clay, and on this clay-soil fine forests of oak-trees came into existence. The great forests of the Weald were famous for their oaks, which in former days contributed largely to the "wooden walls of England." In the western country the Vale of Marshwood was equally celebrated for its oak-trees, and when ships were largely built in the South of England they were much in demand. Many hundreds of fine oak trunks have been taken from the Vale and shipped from Lyme and Bridport. The trade indeed has not entirely ceased, and such cargoes are still embarked at the small port of West Bay, below Bridport; few, however, now come from the Vale of Marshwood, for its woods have disappeared, and the only oaks that remain are hedgerow-trees.

With respect to the isolation of Pilsdon and Lewesdon Hills, this has been effected by the excavation of the intervening spaces; in technical language they are "hills of circum-denudation." The interspaces are the heads of the valleys formed by the action of rain and springs on the slopes of the old watershed. The tributaries of the Axe have trenched it on the north, while on the south side the strong springs thrown out at the base of the Marlstone Sands have eaten backward some little way into the ridge of the original watershed, causing the actual water-parting to retreat northward. This recession has taken place principally near the villages of Pilsdon and Bettiscombe, while Lewesdon may really be very nearly on the site of the original ridge of the watershed.

The same process has taken place near Beaminster, where the spring-heads which furnish the headwaters of the Brit have undoubtedly eaten deep into the Chalk and Greensand area, and there the escarpment is still receding, as the frequent scars of landslips testify.

It will be seen, therefore, that the history of the evolution of the present physical features of West Dorset involves the consideration of many agencies and many conditional phases. Here, as elsewhere, rain, rivers, snow, frost, and heat have been the principal agents at work, but in order to understand how their operation has resulted in the particular arrangement of hills and valleys which we see around us, we must form some conception of the conditions under which they started to work, and we must remember that their working powers have always been guided and modified by the changes in the relative height of sea and land, those slow movements of upheaval and subsidence to which every portion of the earth's crust has been repeatedly subjected.

IV.—A Revindication of the Llanberis Unconformity.

By the Rev. J. F. Blake, M.A., F.G.S.[1]

Preliminary Remarks.

In a paper published in the Quarterly Journal of the Geological Society for 1893,[2] I gave an account of the evidence that led me to conclude that certain conglomerates and associated rocks occurring for some distance north-east and south-west of Llanberis, which had hitherto been considered to lie below the workable Cambrian Slates of that area, were in reality unconformable deposits of a later date than those slates. In the year 1894 Professor T. G. Bonney and Miss C. Raisin published in the same Journal[3] a controversial paper criticizing my statements and conclusions.

It may seem rather late in the day to be replying to a criticism made so long ago, and reasons for the apparent delay must therefore be given. At the reading of their paper before the Society I welcomed it as an attempt to examine the district I had described, and it was only on reading it in full that I realized its true character. I was then just leaving for India, and though a large part of the criticisms might have been replied to at once, there were statements in it which could only be explained and accounted for after another visit to the ground, and this I was unable to make till my return, when I at once presented my reply to the Society—their Journal being, in my opinion, the proper place for it to appear in. As the Council, however, are of a different opinion, such part of my reply as refers especially to the criticisms on my work is here presented in a modified form with additional remarks.

There was nothing in that paper which in any way suggested to my own mind that I might be wrong, but I can well understand that anyone reading it might believe that my conclusions were so ill-founded that a short visit to the district by another observer might suffice to upset them. My object, therefore, here is to show that it is not I but my critics who are in error.

The question whether a certain conglomerate in North-West Carnarvonshire is conformable or not to the underlying rocks may seem at first sight to be of no great consequence, but it involves the larger question as to where the base of the Cambrian system is to be drawn—that is to say, what beds are to be included in or excluded from the Pre-Cambrian series; and this is a matter in which some of the foremost of present and past geologists have interested themselves.

This being the case it is probably unnecessary here to point out the bearings of the several factors involved. It will suffice to note what views of the subject have been taken by different observers, in order to show how far my own views or those of my opponents coincide with or differ from those of others.

[1] The substance of a paper read to the Geological Society on December 1st, 1897, with additional remarks.

[2] Vol. xlix, pp. 441–446.

[3] Vol. l, pp. 578–602.

History of Previous Opinion.

The older view expressed by Sir A. Ramsay in his "Geology of North Wales"[1] (A) is too well known to require much explanation. He regarded the felsite here exposed as a single mass which had intruded into, and in places completely altered, the adjacent conglomerate. He based his view principally on the fact that the matrix of the conglomerate closely resembles the felsite, even to the porphyritic crystals, the passage between the two being quite gradual. We must not suppose that such a geologist as Sir A. Ramsay was misled in this matter, as some subsequent writers have suggested, by so simple a thing as the obscurity of the pebbles in an unweathered block. On the contrary, more than one of these writers have described the rocks in which his statements are verifiable as felsites. Such rocks may be seen near the Llanberis road, on the summit of the felsite crag in the tramway section, on the slopes of Clegyr, and on Mynydd-y-cilgwyn, and here certainly Sir A. Ramsay's explanation is suggested, though further observations, here and elsewhere, render it untenable. When, however, we reject it we must admit that a conglomerate can be deposited on a felsite in such a way that it is impossible to say where one begins and the other ends. His explanation also accounted for "the capricious variation of the strata adjoining the porphyry," which otherwise might have suggested to him an unconformity.

The first attempt to upset Sir A. Ramsay's explanation came from Professor Hughes and Dr. Hicks, the latter publishing his views (B) in 1878.[2] He considered (1) the felsite at Moel Tryfaen to belong to the same series as the rocks in the adit beneath the hill, and (2) both to be overlain unconformably by the conglomerate; but he gave no proof of the latter conclusion beyond a supposed N.W. dip of the "metamorphic rocks," the Cambrian conglomerate having, according to him, a N.E. dip. But he pointed out that the conglomerates contained pebbles "appearing to resemble the rocks *in sitû* near," and stated of these conglomerates that "here, as in all other Welsh areas, they strongly define the base of the Cambrian."

Of the rocks of Llyn Padarn he says, "it is more than probable that we have in the series here some contemporaneous lavas," and "the pebbles in the conglomerates are usually identical in character with the rocks below." He does not, however, point out what is the nature of "the rocks below," though they must have included the felsite.

In 1879 Professor Bonney published a paper on the district (C).[3] It gave the result of "working over parts of the district [including the Bangor area] on several days in September, 1878." From internal evidence it would appear that the author visited Moel Tryfaen and returned by the Bettws Garmon road, walked from Cwm-y-glo to Llanberis by the railway, and returned part of the

[1] Mem. Geol. Survey, vol. iii.
[2] Q.J.G.S., vol. xxxiv, pp. 147–152.
[3] Q.J.G.S., vol. xxxv, pp. 309–320.

way by the road, climbing the slopes above, and also went along the tram-line on the other side of Llyn Padarn from the head of the lake to Llys Dinorwig. He accounts for the differences between himself and "the officers of the Survey" by their being "occasionally misled by the superficial aspect of the rocks."

Part of this paper it is necessary to quote. Speaking of Moel Tryfaen, he says: "The conglomerate contains pebbles of the same purplish quartz-felsite, generally 2–4 inches diameter, but sometimes a foot or more, together with angular fragments of purple slate. On the western side about one-fourth of the fragments are felsite, the remainder slate—green and purple, and a dull green grit resembling one in the underlying series. The fragments of purple slate are rather more numerous on the eastern side. The strike of the conglomerate appeared to be about E.N.E. and W.S.W. . . . and the bedding, as it seemed to us, dipped to the N.N.W. at a high angle, but . . . it was difficult to be sure of this" [Dr. Hicks had made the dip N.E.]. The quartz-felsite he takes to be a lava-flow, because (1) it shows flow-structure in parts; (2) a band of slate is intercalated in it and is not conspicuously altered; (3) it is associated in places with an agglomerate.[1] He also gives a section along the tramway by Llyn Padarn, which will be referred to later on.

One among his conclusions is that "further examination will probably discover more agglomerates, and perhaps further subdivide the lava-flows," and in speaking of Moel Tryfaen, "where the quartz-felsite must be very thick." says, "appearances suggest that there is a marked physical break between this [the Cambrian conglomerate] and the subjacent sedimentary series."

Up to this time, therefore, the only alternative to Sir A. Ramsay's view was, that there was a single conglomerate forming the base of the Cambrian, and that it lay unconformably on, or was separated by, a marked physical break from the rocks below, whether felsitic or sedimentary, whose fragments also its pebbles resembled; the only variation being that Professor Bonney figured the conglomerate in his tramway section[2] as conformable, but said nothing about it in his text.

In 1885 Professor Green (D) described part of this section,[3] which he considered to show that "the conglomerate rests on these rocks with the strongest possible unconformity." As to the age of the conglomerate, he only says that it is "taken to be the base of the Cambrian rocks in that district." At the reading of

[1] All these reasons seem to me to have now disappeared. We have learned that flow-structure may be found also in an intrusive rock (see Sir A. Geikie in G, postea, p. 93), the "slate" is a greenstone dyke, and the agglomerate may be a fault breccia. Even the proof of the felsite being of earlier age than the conglomerate would not now, if that conglomerate is post-Llanberis, prove it to be non-intrusive, and there remains only the fact that it is always followed, in regular succession, by its own débris, or what is considered to be such, and this seems sufficient.

[2] Op. cit., p. 315.

[3] Q.J.G.S., vol. xli, pp. 74–79.

this paper Professor Hughes expressed his agreement that here "the newer series" is "absolutely unconformable to the older," and Dr. Hicks said that "from the present evidence it is clear that an unconformity does exist." Professor Bonney, however, said that Professor Green's reading of the section (which differed from his own) might be the correct one, but he felt very doubtful.

It was this general consensus of recent opinion, that there were Pre-Cambrian rocks exposed in this district, that led me to examine it in connection with the Pre-Cambrian rocks of Anglesey, announcing my results in 1888[1] (E). At the time of writing that paper I was no better acquainted with this part of the district than other writers upon it, but I was led to accept the recent opinions (1) that the felsite was a lava-flow and not intrusive, and (2) that the conglomerate to the east was derived from it. But no evidence had been given for regarding the conglomerate as the base of the Cambrian, and accordingly I considered it might be high up in that series. Nor could I then see proofs of unconformity at Moel Tryfaen, while the unconformity shown by Professor Green I could not deny, but I tried to discount it by quoting his opinion that it did not necessarily indicate any great difference in age.[2] I thus considered the felsite to be part of the Cambrian succession, in spite of accepting all that previous writers had given reasons for. As to the conglomerate, quoting previous observers, I considered that the pebbles were of Cambrian age, and yet took the containing rock to be one of the higher conglomerates in that series.

In 1891 Miss C. Raisin traversed my conclusions as above (F).[3] In this paper, amongst many minor criticisms, she made one of great weight (in addition to the correction about the "slate"). Speaking of Moel Tryfaen, she said: "We should have to believe that at some epoch, after the deposition of one of Mr. Blake's successive conglomerates, the slates of which we now speak were deposited, indurated, modified, and worn down to form some of the Moel Tryfaen pebbles—a process of rapid manufacture indeed." This was used as an argument for an unconformity below the conglomerate, which she was then in favour of, even though she could not observe it in Professor Green's section, where she considered it as only "locally absent."

Five days previous to the reading of this paper Sir A. Geikie treated of the district in his Presidential Address (G).[4] He denied that the conglomerate forms the base of the Cambrian, or is unconformable on the rocks below, and, in fact, he agreed exactly with my then published views. But he could not see the unconformity

[1] Q.J.G.S., vol. xliv, pp. 271–290.

[2] In this same paper I endeavoured to support the Cambrian age of the felsite by finding its base. Therein I mistook a squeezed relic of a dyke for slate, with the result that the section, which I thought proved my point, proved nothing, either for or against it. In a later paper (F) Miss Raisin did me the service of pointing out this mistake, as I have much pleasure in acknowledging.

[3] Q.J.G.S., vol. xlvii, pp. 329–342.

[4] Ibid., Proc.

where Professor Green described it, and was not, therefore, forced as I was to discount its teaching.

In 1892 I published a detailed account of the Cambrian succession (H),[1] from which it appeared that instead of there being only one Cambrian conglomerate at the base, there were several at different horizons in the series. The facts about the Llyn Padarn felsite and conglomerate were postponed to a later paper. This later paper (I), published in 1893,[2] is the one which has been criticized by Professor Bonney and Miss Raisin conjointly in the paper now being replied to (K).[3] Prior to the observations therein recorded, most of which were entirely new, I had considered that there was no unconformity beneath the Llyn Padarn — Moel Tryfaen conglomerate, except the supposed local one shown by Professor Green, but these observations forced me to conclude that Professor Hughes and Dr. Hicks were right in their conjecture that such an unconformity occurred, and that it indicated, in the words of Professor Bonney, a "marked physical break." Notwithstanding this, I still agreed with Sir A. Geikie in considering that there were several conglomerates in the Cambrian series, each in relation to its own felsite, but I removed from that series the great one at Moel Tryfaen and Llyn Padarn.

It thus appears that at that time the whole difference of interpretation rested solely on the question as to what were the rocks on which the conglomerate lay unconformably. Dr. Hicks supposed them to be Pre-Cambrian, because the samples he collected in the Moel Tryfaen adit seemed more altered than the Cambrian rocks with which he was acquainted. I held them to be part of the ordinary Cambrian series. I was accompanied in the examination of the adit section by Mr. Robert Lloyd, who has spent his life amongst these rocks and knows them well, and he recognized them at once by their local names. I also exhibited to the Geological Society samples of all that I collected there, without anyone claiming them as anything but Cambrian.

But, of course, this difference was fundamental. If the conglomerate in one place is unconformable to the rocks immediately below the purple slates, we may reasonably expect that in other places it will be unconformable to the latter also, as they follow the former in regular sequence, and in this case the whole proof of there being anything Pre-Cambrian here is entirely destroyed.

Under these circumstances it is certainly remarkable that Professor Bonney and Miss Raisin, in their criticism upon my paper, do not attempt to show that the rocks in the Moel Tryfaen adit are Pre-Cambrian, but endeavour to demolish my stratigraphy, in which, if successful, they would destroy their own former views and approximate to those which now, on further evidence, I have discarded, and which were nevertheless equally fatal to the idea of there being any proof of the existence of Pre-Cambrian rocks in the district.

[1] Q.J.G.S., vol. xlviii, pp. 243–262.
[2] Q.J.G.S., vol. xlix, pp. 441–466.
[3] Q.J.G.S., vol. l, pp. 578–602.

The various views on this district may now be thus summarized:

A. A general unconformity indicates the commencement of a new series.—*All.*

B_1. There is no unconformity in this district.—*Ramsay*; at Moel Tryfaen, *Bonney, Raisin.*

B_2. The unconformity is local only.—*Geikie*, formerly *Blake.*

B_3. The unconformity is general.—*Hughes, Hicks, Blake*; formerly *Bonney, Raisin.*

Conclusion 1. There is no break in the series here.—*Ramsay, Geikie, Bonney? Raisin?* formerly *Blake.*

Conclusion 2. The great conglomerate forms the base of a new system.—*Hughes, Hicks, Blake*; formerly *Bonney, Raisin.*

C_1. The Moel Tryfaen conglomerate is Cambrian, therefore the underlying beds are Pre-Cambrian.—*Hughes, Hicks*; formerly *Bonney, Raisin.*

C_2. The beds below the Moel Tryfaen conglomerate are Cambrian; therefore there is no evidence of Pre-Cambrian rocks here, and the age of the conglomerate is doubtful.—*Blake.*

Professor Bonney and Miss Raisin's general Objections.

The authors commence by characterizing my conclusions as "a new and revolutionary hypothesis"; but it will be seen from the foregoing account that the idea of an unconformity is by no means new. The nature of the rocks in the Moel Tryfaen adit can scarcely be called a "hypothesis," and it is this that is revolutionary in its results, the further extension of the unconformity, which no doubt is new, being thus rendered quite natural. My suggestion also of there being more than one felsite, had been anticipated by Professor Bonney in C.

As a first objection my critics ask: "To what epoch (from the Menevian onwards) do these so-called Post-Llanberis sediments belong, and where in the adjacent districts may we find beds that can be correlated with them?" "Of this problem," they say, I have not "succeeded in offering a solution." When they wrote this they cannot have considered my words (p. 465): "It seems to me most probable that they are extensions of the immediately overlying rocks." These overlying rocks (the Bronllwyd Grit and its associates) do not belong to any epoch from the Menevian onwards, but lie below that formation and below all fossiliferous rocks, except the Penrhyn pale slates with *Conocoryphe viola.* The authors have totally misunderstood my suggestion; moreover, that suggestion about the probable age of the conglomerate may be wrong without affecting the question of the unconformity.

Next they take me to task for saying that we must see whether this unconformity be local or not, for according to them "it can be no local phenomenon." Plainly it is because I take for granted that a "marked physical break" (Bonney) can be no local

phenomenon that I propose to see whether the supposed break is local or not by way of testing its existence.

The next difficulty is "the necessity of twice uncovering the felsite," which, they say, I have "not even considered." Certainly I have not. Why should not felsite be uncovered twenty times in the course of its history? As I do not understand what the difficulty is, I may be wrong in supposing it to result from a mixture of ideas. It may be their idea that there is in this district an unconformable conglomerate at the base of the Cambrian series, and it is my idea that there is an unconformity above that series. I do not hold both. As to all the conglomerates but one, I accept Professor Hughes' and Sir A. Geikie's explanations as to how a contemporaneous lava-flow may be denuded before it is covered up by any other stratum, and thus yield its pebbles to an overlying conglomerate. It is only when the conglomerate has to lie on the felsite unconformably that the latter wants uncovering.

The next difficulty is thus expressed: "Curiously enough the Llanberis strata, though they have been so completely planed down, have not contributed any large amount of fragments; only exceptionally do we find these or slaty pebbles of any kind, as, for example, at Moel Tryfaen." Here the authors give themselves completely away. If there be a single pebble, exceptional or otherwise, really deposited with the conglomerate and derived from the Llanberis strata, then the former must be younger than the latter. Probably the authors do not mean what the words imply, but for "these" we must understand "pebbles resembling these, but not really derived from them." Even then the statement reads curiously with reference to Moel Tryfaen, after Professor Bonney's description in C, that about three-quarters of the pebbles on the western side are "slate, green and purple," etc., as quoted above, while "on the eastern side the fragments of purple slate are rather more numerous." He then believed in the unconformity. The statement, however, that the Moel Tryfaen conglomerate is exceptional in containing slate pebbles is based on defective information. The slopes of Y Bigl show, in certain parts of the conglomerate, quite a number of purple slate fragments, of such large size and so angular that I really cannot suppose them to have come from any distance; and the workable slates close by are just like them. They are found also on Mynydd-y-cilgwyn and between Moel Rhiwen and Moel-y-ci. We must remember, too, that purple slate is not a kind of rock likely to be left in large fragments far from its source of origin; it would soon break down into mud and form a new rock like the original. Of this we find several examples, which render the stratigraphy difficult.

So far from the alleged absence of pebbles of rocks like the adjoining ones being a difficulty, their frequent presence and their distribution are strongly in favour of an unconformity, as formerly argued by Miss Raisin. It is these slate pebbles that distinguish, when present, the great conglomerate from others which are intraformational. Sir A. Geikie proposed to account for them by the

breaking up of the circumjacent deposits during a volcanic eruption, but this explanation is untenable because, as pointed out by Dr. Hicks, the pebbles are of rocks already cleaved. The conglomerate runs in a long line, and its pebbles change character with the rock near which it lies. Near the felsite it becomes most felsitic. On Y Bigl and further north, as also at Moel Tryfaen and Mynydd-y-celgwyn, where it lies nearest purple slate, the fragments like that rock are most abundant, and where at Moel Tryfaen it approaches nearest the upper side of these slates, it contains strange, unrecognizable fragments. In this it shows the character of a shore deposit.

Although the general objections of my critics are thus disposed of, I do not in the least demur to their conclusion, that "the detailed evidence ought to be of the strongest and clearest nature if it is to establish the supposed unconformity." That is just what it is.

The Moel Tryfaen District.

This is the district in which Professor Bonney (C) argued that there was a marked physical break, and Miss Raisin (F) that we see here the base of a series. But now that I give definite proofs of the unconformity they cannot believe it.

Dealing with the summit conglomerate and the small amount of any conglomerate in the adit section, these authors say "there seems on our theory no other explanation possible than that this conglomerate is faulted out, and the broad outcrop at the summit might be partly due to such disturbance." We are not told, however, what "our theory" is, nor where the conglomerate is faulted out from, nor how much of the broad outcrop "might be" due to such disturbance. This "explanation" is put forward without any detail that should give us the slightest clue to its meaning, and if we try to guess we are confronted with the puzzling remark, "this seems suggested by the changed dip in the associated green grits on the summit." What the dip was previously and how determined we are not told, so I think it useless to speculate on their meaning.

The authors disagree with me when I say that there is no green grit on the summit. I will only remark that the green grit seen by them is not the green grit which I referred to, which was one occurring between the conglomerate and the purple slates, while, so far as I can judge by the dip given, their "green grit" is part of a small band of false-bedded grit associated with a different kind of conglomerate of white weathering pebbles, near the opposite side of the outcrop. Here one block shows the dip they state, N.N.W., while an adjacent block shows the opposite, S.S.E.

Referring to my description of the wide spread of conglomerates and grits on the north side of the hill and their generally horizontal trend in an east-and-west direction, the authors differ from me again, at least by implication. I stated that there was a line of crags showing a dip of not more than 5° to the east, and also in a lower part a lenticle of fine grit running almost horizontally

in a conglomerate. It is not positively stated that these observations are incorrect, but only that "we took the dip on several blocks and surfaces, of which four at least were clearly shown varying from 15°–25° generally to the S. of E. or S.E."; from which it is left to be inferred that these statements are incompatible with mine. But they are not. I have seen "blocks and surfaces" showing the dips mentioned, but they are isolated blocks lying on the eastern slope of the hill, and it is not certain that they are *in sitû*. I did not even look for dips on such blocks, as dips are worse than useless unless the rocks are certainly *in sitû*. But even in that case these dips, combined with the more persistent ones of the crags, would not affect my argument to any material extent. But with such rocks as these, and so exposed on the slopes of a rounded hill, it is not by isolated dips, which are liable to all kinds of accidents, but by the direction of the outcrops that the strike may best be determined. In this case, if we walk on a level line round the base of the north side of the hill a little above the pathway, we keep on conglomerate, but if we anywhere mount a little and take another contour-line, we keep upon grits. This would indicate that the junction between them, i.e. bedding of both, was not far removed from the horizontal in a direction across the hill.

The further remarks about this district are—(1) That the conglomerate of the lower crags is not like that of the summit, as it does not contain the large slate pebbles. It is true that the pebbles of cleaved rock with the appearance of slate are not so large as in the latter, but there are many of them. (2) That whereas I said of a certain area that it was all covered with conglomerate and grit, in fact no small part consists of unbroken sward. This is only true of that part which I called "the lower slopes," and which I distinguished from the part all covered with conglomerate and grit. (3) That it is remarkable that the conglomerate, if unconformable, does not spread over on to the purple slates. This has not been proved to be the case, and if true is easily explained. The fault which bounds the purple slates is probably a thrust-plane which lifted them and their covering above the level of the conglomerate on the other side, and they have been worn back to that level by denudation, which necessarily first removed the conglomerate. Probably also ice has swept all débris away.

In this district, then, my critics have brought no valid objections against my conclusions, and have failed to propose any reasonable alternative. Meanwhile they have not touched the argument from the great spread of the conglomerate and its associates over a very wide area on the surface of the hill, while nothing but a 3 feet band is found in the adit,[1] nor the still more cogent argument that, whereas the conglomerate here lies on, or is next to, a great mass of banded slate, in the neighbouring hill of Mynydd-y-cilgwyn it lies entirely on felsite, and continues round to the western side of it.

[1] I might add that this is not quite like the summit conglomerate, but such arguments are of little value.

But I cannot understand what they would gain by success in their contention. If instead of one unconformable conglomerate it were granted that there were two or three conformable ones, they would belong to the adit series, or to the purple slate series, or to both, but in no case could they be the base of the Cambrian system, or give any assistance in proving the existence of Pre-Cambrian rocks in the neighbourhood.

(*To be continued.*)

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—February 2, 1898.—Dr. Henry Hicks, F.R.S., President, in the Chair.

The President announced that Dr. Charles Barrois, Secretary of the Organizing Committee of the Eighth International Geological Congress, which will be held in Paris in 1900, would shortly come to London to invite the Geological Society to the Congress, and to consult the Fellows with regard to the proposed excursions and the subjects of discussion.

The following communications were read:—

1. "Contributions to the Glacial Geology of Spitzbergen." By E. J. Garwood, Esq., M.A., F.G.S., and Dr. J. W. Gregory, F.G.S.

The extent of glaciation of Spitzbergen has been exaggerated, for there is no immense ice-plateau, but normal glaciers with some inland sheets and Piedmont glaciers. These differ from Alpine glaciers, as they are not always formed from snow-fields at the head, and though some of the glaciers (as the Baldhead Glacier) have tapering snouts in front, most have vertical cliffs. Chamberlin's explanation that the latter are due to the low angle of the sun is insufficient, and they seem to be caused by the advance of the ice by a rapid forward movement of its upper layers. The ice of these upper layers falls off and forms talus in front, over which the glacier advances, carrying detritus uphill with it, and producing a series of thrusts. The Booming Glacier illustrates cases of erratics carried in different directions by the same mass of ice.

The deposits of the Spitzbergen glaciers are of four types:—(1) moraines of Swiss type; (2) those formed mainly of intraglacial material; (3) those formed of redeposited beach-material; (4) deposits of glacial rivers and reassorted drifts. The materials of the second are subangular and rounded; scratched and polished pebbles and boulders are abundant, and the fine-grained matrix, which is frequently argillaceous, is often well laminated and false-bedded. Some of these drifts are stratified, others unstratified, and contorted drifts occur. This type of moraine is remarkably like some British Boulder-clay. The third class is sometimes formed by land-ice, at other times beneath the sea; the latter shows stratification. The

superglacial and intraglacial streams, so far as seen, were usually clear of drift. Under the fourth head an esker in a tributary of the Sassendal is described.

The direct geological action of the marine ice is of four kinds: transport of material, contortion of shore-deposits, formation of small ridges of boulder-terraces above sea-level, and striation, rounding, and furrowing of rocks along the sea-shore.

Traces of former glaciation are described in the case of the Hecla Hook beds, and of certain beds of late Mesozoic or early Cainozoic age in Bunting Bluff.

Under the head of general conclusions, the authors state that they have discovered no certain test to distinguish between the action of land-ice and marine ice; that there is no evidence to prove that land-ice can advance far across the sea; and that there is evidence, which they regard as conclusive, of the uplift of materials by land-ice. They note that the mechanical processes connected with the advance of the glaciers are of three kinds. All the material seen transported by the glaciers was superglacial or intraglacial, and not subglacial. Some striation of intraglacial material is caused by differential movement of different layers of ice. The advance and retreat of the Spitzbergen glaciers is very irregular, and apparently due to local changes. The observations of the authors support the views of those who ascribe a limited erosive power to glaciers. Lastly, the theory that glacial periods occurred as a consequence of epeirogenic uplifts receives no support from Spitzbergen.

2. "On a Quartz-rock in the Carboniferous Limestone of Derbyshire." By H. H. Arnold-Bemrose, Esq., M.A., F.G.S.

The paper describes the occurrence in the field and the microscopic structure of a rock consisting essentially of quartz, which is found in the Mountain Limestone in several localities. It occurs in irregularly-shaped bosses and veins, and shows no signs of stratification.

Its close association with a quartzose limestone, which in turn passes into an ordinary limestone with few, if any, quartz-crystals, leads to the inference that it is a silicified limestone.

The microscopical structure of a number of thin slices of these rocks is described. The quartz-rock is seen to be made up of quartz-grains which generally interlock closely, but sometimes possess a crystalline outline and contain zones of calcite. Fluor is occasionally present.

The quartzose limestone is usually a foraminiferal limestone containing a large percentage of quartz, which occurs as separate crystals and as aggregates of crystals. The latter and the small quartz-veins have a structure similar to that of the quartz-rock. The former often contain zones of calcite and penetrate organisms. The residue consists of quartz-crystals.

The author considers that the quartz-rock is not a gritty limestone, altered by the growth of crystalline quartz around the detrital grains, but that it is a limestone replaced by quartz. The gradual

passage from the quartz-rock through a quartzose limestone to an ordinary limestone, the presence of chert, of part of a foraminifer, and of pieces of quartzose limestone in it, support the opinion that it is an altered limestone.

II.—Annual General Meeting.—February 18, 1898.

Dr. Henry Hicks, F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1897. In the former the Council referred to the uninterrupted financial prosperity of the Society and to the continued increase in the number of Fellows.

During 1897 the number of Fellows elected was 59: of these 41 qualified before the end of the year, making, with 13 previously elected Fellows, a total accession of 54 in the course of the twelve-month. During the same period, the losses by death, resignation, and removal amounted to 51, the increase in the number of Fellows being 3.

The total number of Fellows, Foreign Members, and Foreign Correspondents, which on December 31st, 1896, was 1,329, stood at 1,333 by the end of 1897.

The balance-sheet for the year 1897 showed receipts to the amount of £3,610 19*s.* 3*d.* (including a balance of £768 3*s.* 0*d.* brought forward from the previous year), and an expenditure of £2,887 16*s.* 3*d.* There was an actual excess of expenditure over current receipts of £45, but the excess was entirely due to expenditure of a non-recurring character, and there still remained at the end of 1897 a balance of £723 3*s.* available for the extraordinary expenditure contemplated in the estimates submitted to the Fellows.

The completion of Vol. LIII of the Society's Quarterly Journal was announced, as also the publication of No. 4 of the Record of Geological Literature added to the Society's Library, and of Part II of the General Index to the first Fifty Volumes of the Quarterly Journal.

An address was presented to Her Majesty by the President and Council, on their behalf and on that of the Fellows, on the occasion of the Sixtieth Anniversary of her Accession; and three delegates were nominated to represent the Society at the International Geological Congress held at St. Petersburg.

The attention of the Council had been drawn by Sir Archibald Geikie to the manuscript, in the Society's possession, of part of the Third Volume of Hutton's "Theory of the Earth." He had freely offered his services as editor, and it was proposed to print and publish the work during the present year.

Reference was also made to the work done by the Committee appointed in connection with the International Catalogue Committee, and to the Index slips issued with the current number of the Quarterly Journal.

In conclusion the awards of the various medals and proceeds of donation funds in the gift of the Society were announced.

The report of the Library and Museum Committee enumerated the large additions made to the Society's Library during the past year, and referred to the continuance of the work of labelling and registering the specimens in the Museum by Mr. C. Davies Sherborn.

In handing the Wollaston Medal (awarded to Professor Ferdinand Zirkel, F.M.G.S., of Leipzig) to Mr. J. J. H. Teall, for transmission to the recipient, the President addressed him as follows:—Mr. Teall:—

The Council of the Geological Society have this year awarded the Wollaston Medal to Professor Zirkel, as a mark of their appreciation of the great services which he has rendered to Geological Science, especially in the department of Petrology. His "Lehrbuch der Petrographie," the first edition of which was published more than thirty years ago, is an indispensable adjunct to the library of every petrologist. A comparison of the two editions of this monumental work, the second of which has only recently appeared, illustrates in a most striking manner the enormous advance which has taken place in petrographical science during the interval—an advance in no small measure due to the influence exerted by Professor Zirkel, both as a teacher and as an original worker.

His classic memoir on the "Microscopic Structure and Composition of Basaltic Rocks" was one of the first publications in which the results of the examination of an extensive series of microscopic sections were made known. It marks an epoch in the history of petrography, not only because it greatly extended our knowledge of this important group of rocks, but also because it gave a great stimulus to the study of thin sections under the microscope. It must always be a source of gratification to British geologists that this important work was dedicated to our distinguished Fellow and revered master, Henry Clifton Sorby.

It is impossible for me to review all Professor Zirkel's important contributions to Geological and Mineralogical Science, but there is one other that I cannot pass over in silence. I refer to his "Geological Sketches of the West Coast of Scotland." In this memoir Professor Zirkel applied the methods of microscopic analysis, for the first time, to the wonderful records of Tertiary volcanic activity which abound in that region. As an original observer he has made his mark in the history of our time, and as a Professor he has won the esteem and affection of many enthusiastic students. It only remains for me now to request you to transmit to Professor Zirkel this Medal, and at the same time to express to him our great regard and our sincerest wishes that he may long enjoy health and strength to continue his important researches in those branches of Geological Science for which he has already done so much.

Mr. Teall, in reply, read the following letter, which he had received from Professor Zirkel:—"Mr. President,—

"The honourable award of the Wollaston Medal is for me one of the most gladdening events of my life. Yet I cannot say whether I am more pleased or surprised at the unexpected announcement that I should be considered worthy of so brilliant a distinction, which has been bestowed by this highest tribunal of Geology only on the most illustrious British and Foreign votaries of the science. But to-day all feelings are merged in one of gratitude to the Members of the Council, who have taken so generous and favourable a view of my modest labours. As, much to my regret and disappointment, I find myself unable to attend the Annual Meeting, I must trespass upon your kindness to express by these written words my heartfelt thanks and best acknowledgment for the great honour conferred upon me, of which the most ambitious may well be proud. I receive the Medal as a token of indulgence and encouragement, and it will be an incentive to me still to strive to be more worthy of it and of your confidence. Probably I never should have been able to do what I have done, but for the wise example and kind instruction of my old master, Henry Clifton Sorby. The tie of personal friendship which connects me with so many fellow-workers in your country since those bygone days, when Murchison, Lyell, and Ramsay favoured the young foreigner with their attachment—this tie will be strengthened to-day, and the Geological Society's prosperity and usefulness will never cease to be the object of my warmest wishes."

The President then handed the balance of the proceeds of the Wollaston Donation Fund (awarded to Mr. E. J. Garwood, M.A., F.G.S.) to Mr. A. Strahan, for transmission to the recipient, addressing him as follows:—Mr. Strahan,—

At the last Meeting of the Geological Society we had the pleasure of listening to a communication by Mr. Garwood and Dr. Gregory which adds much to our knowledge concerning the Glacial Geology of Spitzbergen. Last year he also gave an address at one of the "At Homes" of the Society, which was highly appreciated by those present. These amply testify to his ability to carry on explorations in difficult regions, where strength of purpose and special training are indispensable to success. Other geological questions have also occupied his attention; and I may here mention the paper by him in the Geological Magazine on "Magnesian Limestone Concretions" as an interesting contribution to a vexed question, and his paper and reports on Carboniferous Fossils, the result of much labour among the Carboniferous rocks of the North of England. The Council, in making him this Award, hope that it may act as a stimulus to further researches in those fields in which he has already shown such marked ability, and that he will accept it also as a token of appreciation for what he has already accomplished.

Mr. Strahan, on behalf of the recipient, read the following reply:—"Mr. President,—

"I desire to thank you and the Council of this Society for the honour conferred upon me in awarding to me the Balance of the Proceeds of the Wollaston Fund.

"Some years ago, it occurred to me that the Carboniferous beds in Britain might be capable of subdivision into life-zones, similar to those already established in Belgium and elsewhere; but, after several years' work, I realized that the task was much too great for the time at my disposal, and I am glad to say that the work is now being carried on by a Committee of the British Association.

"My last two summers have been devoted to work in the far North; and the kind encouragement and assistance which I have received to-day will be a great incentive to the continuance of that work."

The President then handed the Murchison Medal (awarded to Mr. Thomas F. Jamieson, F.G.S.) to Mr. Horace B. Woodward, for transmission to the recipient, addressing him as follows:—Mr. Horace Woodward,—

The Murchison Medal, with the sum of Ten Guineas, has this year been awarded by the Council of the Geological Society to Mr. Thomas F. Jamieson, in recognition of his long and important researches among the Glacial Deposits of Scotland. It is an interesting fact that Mr. Jamieson's first papers were communicated to this Society through Sir R. Murchison, the founder of this Medal. From the year 1858, when he read a paper before the Society on the Pleistocene Deposits of Aberdeenshire, up to the present time, Mr. Jamieson has continued his researches with unabated enthusiasm, and the Geological Society has received many valuable communications from him. The list includes papers on "Drift and Rolled Gravel of Northern Scotland" in 1860, and "Ice-worn Rocks of Scotland," 1862, in which he describes great erosion by ice-action and the presence of boulders far above the parent rock, and gives a sketch-map of Scotland showing the direction of the Glacial markings. In 1863 was published his well-known paper on the Parallel Roads of Glen Roy, in which he claims that they are beaches of fresh-water lakes—the lakes having originated from glaciers damming the mouths of valleys and reversing their drainage. Further papers on Glacial questions were communicated by him to the Society in 1865, 1866, 1871, 1874, 1882, and 1891, and he may, I think, claim to have done more probably than any other man for the Glacial Geology of Scotland. It must not be forgotten also that this Society always received the first fruits of his labours, and that his most important papers are to be found in our Quarterly Journal. These papers are full of carefully observed facts, and abound in valuable suggestions, and many of the views advocated by him in some of his earlier papers have been since further advanced by him and other observers in this and other countries. I will ask you, therefore, to be good enough, in

transmitting this Medal to Mr. Jamieson, to express to him the admiration of the Council for the energy and ability with which he has for so long a period, and with such signal success, prosecuted researches among the newer deposits in Scotland.

Mr. Horace B. Woodward replied in the following terms:—Mr. President,—

I esteem it an honour to receive this Medal on behalf of Mr. Jamieson, for no one has laboured more ardently, no one more successfully, than he, in interpreting the Pleistocene records of North Britain. He bids me say:—

"I regret much that my distance from the Metropolis will not allow me to be present at the Annual Meeting of the Society. It has also prevented me from taking any part in the pleasant Evening Meetings, which I regret even still more. I think I have been present on only one occasion, and that was before I became a Fellow of the Society, which is a good long while ago.

"It is gratifying, however, to find that, although so far away, and so little known personally to the Council of the Society, they have not only kept me in remembrance, but have done me the honour of awarding to me the Murchison Medal. This I shall value the more as it recalls the recollection of the warm-hearted Sir Roderick, from whom I received much kind attention many years ago. Although then a young man, and quite a stranger to him, I found no one more ready to help me in every way that he thought would be useful. This was a bright feature in his character, which struck me much at the time, and has always kept his memory green in the breast of the present recipient of his Medal."

I may add that I am sure that Mr. Jamieson will be gratified by the kindly remarks which you have made in reference to his work.

In handing the balance of the proceeds of the Murchison Geological Fund (awarded to Miss J. Donald, of Carlisle) to Mr. E. T. Newton, for transmission to the recipient, the President addressed him as follows:—Mr. Newton,—

On one occasion only has the Geological Society previously granted an Award from its Funds to a Lady. This was in the year 1893, when Miss Raisin, so well known to us by her petrographical and stratigraphical work, was the recipient. On the present occasion a lady who has attained distinction as a palæontologist has been selected by the Council to receive an award from the Murchison Fund, and the Fellows generally will, I feel sure, believe that in making this Award to Miss J. Donald the Council has acted wisely and justly. In the Quarterly Journal of this Society are five important papers by Miss Donald. The first, in the year 1887, "Notes upon some Carboniferous Species of *Murchisonia*"; followed in 1889 by "Descriptions of some New Species of Carboniferous Gasteropoda"; in 1892, "Notes on some New and Little-known Species of Carboniferous *Murchisonia*"; in 1895, "Notes on the Genus *Murchisonia* and its Allies"; and, in the forthcoming Quarterly Journal, "Observations on the Genus *Aclisina*, De Kon., with Descriptions of British Species and of some other Carboniferous Gasteropoda."

Previous to taking up the study of fossil shells, which I understand she did at the instigation of Mr. J. G. Goodchild, F.G.S., Miss Donald had well prepared herself by previous studies of recent shells, and we find in the Transactions of the Cumberland and Westmoreland Association of Literature and Science, so far back as 1881, some notes by her on the "Land and Fresh-water Shells of Cumberland." Miss Donald has not only visited very many of the collections in this country, but also those in the Continental museums, for the purpose of studying fossil shells, and she is still untiring in her zeal in collecting information for future work. When transmitting this Award to Miss Donald you will be good enough to say that the Council hope it will be accepted, not only as a token of appreciation of the excellent work which she has already accomplished, but in the hope that it may be some incentive to her to continue her palæontological researches among the Palæozoic rocks.

Mr. Newton, in reply, said:—Mr. President,—

It is with peculiar pleasure that I receive this Award on Miss Donald's behalf, for it is a rare occurrence for a lady to receive one of the Society's Awards, and having

for some years watched and appreciated the conscientious and painstaking labour by which Miss Donald has accomplished a very admirable piece of work, it is particularly gratifying to find that this work has met with the appreciation of the Council of the Geological Society.

As Miss Donald cannot be present to receive this award personally, perhaps I may be allowed to read an extract from her letter:—

"Will you thank the President and Council most heartily on my behalf for the great honour which they have conferred by awarding to me the balance of the proceeds of the Murchison Fund. The news came to me as a great surprise, for I had previously deemed it no small honour that my papers should have been considered worthy of publication in the Quarterly Journal of the Society, and this higher recognition will certainly prove an encouragement to further research and, I hope, better work. My studies have been a source of great pleasure to me, and I feel that there is still much to be found out, even with regard to the genus *Murchisonia*, to which I have hitherto devoted the greater share of my attention."

The President then handed the Lyell Medal (awarded to Dr. Wilhelm Waagen, F.G.S., of Vienna) to Dr. W. T. Blanford, for transmission to the recipient, addressing him as follows:—Dr. Blanford,—

Owing to ill-health, Dr. Waagen is unable to be present to receive the Lyell Medal, with the sum of twenty-five pounds, which the Council of the Geological Society have awarded to him, in appreciation of his excellent Palæontological work. Just twenty years ago (Feb. 1878) Dr. Waagen was a recipient of the Lyell Fund, soon after his retirement, owing to ill-health, from the Geological Survey of India; and his work was, on that occasion, referred to in terms of great admiration by the then President, Prof. Martin Duncan, and by Dr. Oldham, who was deputed to receive the Award on his behalf. Of the works published by Dr. Waagen, I may mention an important paper, "On the Classification of Upper Jurassic Beds" (those of Southern England included) in 1865, and in 1869 one on "The Subdivisions of Ammonites," of which full abstracts appeared in the Quarterly Journal of the Geological Society in 1865 and 1870. When in India he described the Ammonites of the Kach Jurassic beds, and his great knowledge of the Ammonitidæ enabled him to work out the succession in detail. Another most important work was his description of the fossils from the Cambrian, Carboniferous, Permian, and Triassic of the Salt Range in the Panjâb, and his account of the geology in the "Palæontologia Indica." His untiring devotion to his work is well known to all those who have been in any way associated with him, and his careful and zealous labours have placed him in the front rank of palæontologists. I now ask you to be good enough to forward to Dr. Waagen this further token of esteem, with every expression of good-will, from the Council of the Geological Society.

Dr. Blanford replied in the following terms:—Mr. President,—

I am glad that I am able to comply with the request of my old friend and colleague Dr. Waagen, that I would represent him on this occasion and receive for him the Lyell Medal of the present year.

May I be allowed to express my own gratification at the award? Few geologists, I think, will question the value of the Palæontological work done in connection with the Geological Survey of India since that Survey was first organized under the late Dr. Thomas Oldham. Dr. Waagen is now the only survivor of the first three Palæontologists who between them occupied the post from 1862 to 1883. As, moreover, Dr. Waagen has been continuously engaged in the study of Indian Palæontology, and in contributing to the Survey publications, from the date when he first joined the Indian Survey to the present day, he is the author of a much larger share of the work than either of his colleagues.

As you, Sir, have already stated, the proceeds of the Lyell Fund were awarded to Dr. Waagen just twenty years ago, in 1878. There has rarely, I believe, been an occasion on which the intentions of the great geologist who founded this fund have been more thoroughly carried out. Sir Charles Lyell desired that the interest of this fund should be given for the encouragement of Geology or of any of the allied sciences by which Geology has been most materially advanced. At the time when the fund was awarded Dr. Waagen had left India, broken in health, and in serious

difficulty through having to resign his appointment on the Indian Survey, on account of his inability to resist the effects of a tropical climate. I know as a fact that the Award was a great encouragement to him, and I think the volumes which he has since published in the "Palæontologia Indica," containing his descriptions of that marvellous series of Salt Range fossils from Lower Cambrian to Trias, and his masterly summary of the Geological results, have thoroughly justified the award that was made.

In a letter which he wrote to me recently, Dr. Waagen said: "The decision of the Geological Society's Council to award to me the Lyell Medal is greatly gratifying to me, and I have to express to the Society my most heartfelt thanks. These I beg you to express to the Society, as my health is yet too untrustworthy for me to go to London and do so myself. I hope yet to do some work, though my chief work has been done. I hope to finish the Indian Trias; the Nautilidæ and Gasteropoda are in manuscript finished, and the Pelecypoda will soon be commenced. I hope to finish the whole by the end of this year.

"The Medal will give me a new impulse to go on with the work. . . . . So I beg you to receive it on my behalf and to express my most hearty thanks to the Society for it."

It only remains for me, Sir, to thank you on behalf of Dr. Waagen for having added to the value of the Medal by the manner in which you have spoken of his services to science.

In presenting to Mr. H. Woods, M.A., F.G.S., a moiety of the balance of the proceeds of the Lyell Geological Fund, the President addressed him as follows:—Mr. Woods,—

The Geological Society has already received some important communications from you, and I hope that these will be followed by many others. In your paper on the Igneous Rocks of the Neighbourhood of Builth you have successfully applied not only your petrological knowledge, but also your palæontological experience in working out the stratigraphy of an interesting and complicated region; and your paper on the Fossils of the Middle Chalk is a very valuable contribution to the study of the Fauna of the British Cretaceous Rocks. Your "Catalogue of Type Fossils in the Woodwardian Museum" is indispensable to all working palæontologists; and your "Elementary Palæontology," written primarily for Cambridge students, has been found so useful that it is now, I understand, adopted as a textbook, not only in many places in Britain, but also in the Colonies and in America. I have much pleasure in handing to you this Award on behalf of the Council of the Geological Society, in testimony of your past work, and in the hope that it may be of some aid to you in your future labours.

Mr. Woods, in reply, said:—Mr. President,—

It is with much pleasure and gratitude that I receive this fund which the Council have been good enough to award me; and I can assure you, Sir, that I shall lose no opportunity of continuing the work to which you have referred. Although the greater part of my time is occupied by official duties in the lecture-room and museum, yet it is encouraging to hope that, as a teacher, I may be an indirect means of helping forward palæontological investigation.

In my "Catalogue of Type Fossils in the Woodwardian Museum," of which you have so kindly spoken, I endeavoured to give not only a list of types, but also a record of the persons who have enriched the collections in our museum, and amongst those benefactors you, Sir, occupy a prominent place.

The President then presented the other moiety of the balance of the proceeds of the Lyell Geological Fund to Mr. W. H. Shrubsole, F.G.S., addressing him as follows:—Mr. Shrubsole,—

For many years your name, as well as that of two of your brothers, has been well known to the Fellows of this Society, and it is a pleasure to me to hand to you, on behalf of the Council, this moiety of the Lyell Fund, in testimony of the valuable services rendered by you to Geological Science.

Although during your long residence at Sheerness you were engaged in business, you lost no opportunity of advancing the science of Geology, to which you had

become so ardently attached, and by your exertions you greatly added to our knowledge of the Fauna and Flora of the Lower Eocene of the Isle of Sheppey.

Amongst your discoveries, which have been described in the Quarterly Journal of this Society, may be mentioned the wing-bones and skull of a bird allied to the albatross, named by Owen *Argillornis longipennis* (Quart. Journ. Geol. Soc., 1878); a new genus and species of Estuarine Gasteropods, described by Lieutenant-Colonel Godwin-Austen in 1882; and the remains of a giant turtle, named by Owen *Chelone gigas* (Quart. Journ. Geol. Soc., 1889). I understand that your collections of fossil fruits were also of great use to Baron von Ettingshausen and Mr. Starkie Gardner in working out the Flora of the Eocene; and that all your choicest specimens (including another new bird's skull) have been always transmitted to the British Museum so soon as discovered. Those who are acquainted with your labours will feel that this Award of the Council has been given to a thoroughly meritorious fellow-worker, and a most patient original scientific investigator.

Mr. Shrubsole replied in the following terms:—Mr. President,—

This part of the present proceedings has made me realize that, once again in my experience, the unexpected has happened. Only this time, unlike many previous experiences, the unlooked-for circumstances are, so far as I am concerned, entirely pleasant and beneficial. In view of what has happened, I am constrained to say that it affords me very great gratification that this distinguished Society has seen fit to include me in its roll of honour, and to present me with a substantial mark of its favour.

It is, indeed, very pleasant to me to find that the geological work carried on quietly and alone for a good many years has now received ample recognition, and has had the stamp of your approval bestowed upon it. Although I had no co-workers in Sheppey from whom to derive encouragement and assistance, yet I always met with kind and helpful attention from all geologists with whom occasionally I came in contact. I have never applied to any Fellow of this Society, or to any official of our Museums, for help in the determination of specimens, without obtaining all that I wanted; and the value of this was enhanced by the extremely courteous way in which it was rendered.

There are gentlemen here—there are others who have passed away—whom I shall always remember with gratitude, for having thus assisted me when I was a geological neophyte. As to the future; I hope that I may be able to render some further scientific service.

It is true, as you can see, that I am no longer troubled with the immaturity of youth, yet I feel that a reserve of energy remains, for which I hope opportunity of exercise may still be found.

Although I no longer reside at Sheppey, I am keeping in touch with the place and am well represented there. You may rely upon it that no new or rare fossils will escape notice through any lack of attention on the part of my helpers or myself. In this and in other ways I hope to manifest a keen interest in geological pursuits so long as life shall last.

In presenting to Mr. E. Greenly, F.G.S., a portion of the proceeds of the Barlow-Jameson Fund, the President addressed him as follows:—Mr. Greenly,—

The Council of the Geological Society have awarded to you the sum of twenty pounds from the Barlow-Jameson Fund, in recognition of your scientific labours, and to aid you in the important researches which you are now so assiduously carrying on among the older rocks in Anglesey. The experience which you gained when on the staff of the Geological Survey in the North-West of Scotland has enabled you already to attack some of the problems connected with the older rocks with much success; and many are looking forward with great interest to the further results of your labours. I must not omit to mention that, though no longer a member of the Geological Survey, you have continued to work as assiduously, and with the same attention to minute details, as when on that staff, and that the expenses, which must have been considerable, have been hitherto defrayed out of your private income. This is a strong testimony to the love which you entertain for that science which you were led to adopt as a profession, mainly, I believe, through attending the lectures of Professor Bonney at University College, London. It gives me much pleasure to hand you this Award on behalf of the Council.

Mr. Greenly, in reply, said:—Mr. President,—

I wish to express my sincerest thanks to the Council of this Society for the great honour which they have conferred upon me. It is also, Sir, additional pleasure to receive it at your hands, when I think of your own pioneer researches in the same field. With regard to my own work, its present field was chosen because I wished to continue to utilize the experience and training for which I am so deeply indebted to the Geological Survey. Mapping itself I continue to do, not merely because I have faith in it as a method of research, but because it is a pleasure, and I know of no more delightful employment. Nevertheless it is a method which involves much that might be called drudgery, with no apparent reward. At such times this Award will ever be an encouragement to persevere, as I hope to do while I have strength and opportunity.

The President then proceeded to read his Anniversary Address, in which he first gave Obituary Notices of several Fellows and Foreign Members deceased since the last Annual Meeting, including J. J. Steenstrup (elected F.M. in 1879), A. des Cloizeaux (elected F.M. in 1884), T. C. Winckler (elected F.C. in 1874), E. D. Cope (elected F.C. in 1881), O. Fraas (elected F.C. in 1897), Rev. P. B. Brodie (elected a Fellow in 1834), J. C. Moore (elected in 1838, Secretary in 1846), S. Allport (elected in 1869), Brooke Cunliffe (elected in 1845), Rev. S. Haughton (elected in 1853), Sir A. W. Franks (elected in 1867), Rev. R. Hunter (elected in 1868), S. Laing (elected in 1858), H. Drummond (elected in 1877), and Sir J. Maitland (elected in 1890).

He then dealt with the Evidence of the Antiquity of Man obtained from Ossiferous Caverns in Glaciated Districts in Britain, and maintained that the remains of the extinct mammalia found in them must have been introduced before any of the Glacial deposits now in or upon them could have been laid down: therefore either before, or so early in, the Glacial period that there could not have been at the time any considerable amount of snow on the neighbouring mountains, or glaciers even in the higher valleys.

From caverns in glaciated areas in North and South Wales, where Palæolithic implements have been found in association with remains of the extinct mammalia, facts have been obtained which make it certain that the implements were those of man living at the same period as the extinct animals in those areas, and therefore of Pre-Glacial age. It has also been shown that, as the cold increased, the higher valleys became filled with glaciers and the caverns became uninhabitable. That afterwards, as the snow-line and glaciers descended lower and lower, some of the caverns were subject to inundations, which not only disturbed and rearranged the deposits previously in them, but wholly or partially filled them up with local materials. That in the Vale of Clwyd, North Wales, the local glaciers gradually coalesced with those from the western and northern areas, and a mixed material was distributed over the district to a height of over 600 feet, burying the ossiferous caverns beneath it. During this time also water re-entered some of the caverns, redisturbing in part the earlier contents and depositing some of the mixed drift over that previously accumulated in the caverns.

While these caverns were occupied as dens by the hyænas, northern and southern animals commingled in the valleys and on the great plains reaching out from them to the area now covered by the Irish Sea.

From numerous examinations made of undisturbed Glacial deposits in Wales, the North of England, and Scotland, it has also been proved very clearly that the extinct mammalia, whose remains are found in association with the implements of Palæolithic man in caverns, must have lived there before those deposits had been laid down, as their remains always occur at the base or in the lower parts of the drift, and never above it. Further, there is not a particle of evidence to show that the extinct mammalia ever revisited those areas after the close of the Glacial period.

The ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council*: W. T. Blanford, LL.D., F.R.S.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; Prof. W. Boyd Dawkins, M.A., F.R.S.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S.; F. W. Harmer, Esq.; R. S. Herries, Esq., M.A.; Henry Hicks, M.D., F.R.S.; Rev. Edwin Hill, M.A.; G. J. Hinde, Ph.D., F.R.S.; W. H. Hudleston, Esq., M.A., F.R.S., F.L.S.; Prof. J. W. Judd, C.B., LL.D., F.R.S.; J. E. Marr, Esq., M.A., F.R.S.; Prof. H. A. Miers, M.A., F.R.S.; H. W. Monckton, Esq., F.L.S.; E. T. Newton, Esq., F.R.S.; Prof. H. G. Seeley, F.R.S., F.L.S.; Prof. W. J. Sollas, M.A., D.Sc., LL.D., F.R.S.; A. Strahan, Esq., M.A.; J. J. H. Teall, Esq., M.A., F.R.S.; Prof. W. W. Watts, M.A.; W. Whitaker, Esq., B.A., F.R.S.; Rev. H. H. Winwood, M.A.; A. S. Woodward, Esq, F.L.S.

Officers:—*President*: W. Whitaker, Esq., B.A., F.R.S. *Vice-Presidents*: Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; Prof. J. W. Judd, C.B., LL.D., F.R.S.; J. J. H. Teall, Esq., M.A., F.R.S.; Rev. H. H. Winwood, M.A. *Secretaries*: R. S. Herries, Esq., M.A.; Prof. W. W. Watts, M.A. *Foreign Secretary*: Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer*: W. T. Blanford, LL.D., F.R.S.

III.—February 23, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On some Submerged Rock-Valleys in South Wales, Devon, and Cornwall." By T. Codrington, Esq., M. Inst. C. E., F.G.S.

The author describes various valleys in which the solid rock is reached at a considerable depth below sea-level, on the sides of Milford Haven and in the Haven itself; beneath the Tivy, Tawe, and Neath, the Wye, the Severn, the Bristol Avon, the Dart, the Laira, the Tavy, the Tamar, and other rivers. In the case of the Dart the rock-bottom has been found at one place at a depth of 110 feet below water-level, and in the case of other rivers at various depths less than this. The deposits show that some of the infilling took place after the period of submerged forests, and much before this, for frequent cases of glacial deposits filling the bottoms of these submerged valleys are recorded.

The fact that in the Solent and Thames the glacial deposits border the sides of the valleys, and do not occur at the bottom as in the case of the valleys described in the paper, indicates that the latter are older than the former, though they present features similar to those of some of the valleys of the North-East and North-West of England.

2. "Some New Carboniferous Plants, and how they contributed to the Formation of Coal-Seams." By W. S. Gresley, Esq., F.G.S.

The author, in a paper published in abstract in the Society's Quarterly Journal for May, 1897 (vol. liii, p. 245), argued that certain brilliant black laminæ in coal, and similar materials found among some mechanical sediments of the Coal-measures, pointed to the former existence of an aquatic plant. In the present communication he describes structures in the pitch-coal laminæ of bituminous coal and in the glossy black layers of anthracite which he believes to be indications of two other kinds of plants, and states that he has examined structures which may be due to some other kinds of vegetation.

CORRESPONDENCE.

THE FORMATION OF SOIL.

Sir,—That the mode of formation of surface-soil is generally supposed to be due chiefly to the accumulation of the dust and ashes of dead vegetable matter and of animals, and their ceaseless action while alive within and upon it, and to the decomposition of the subsoil or of the rocks immediately below the soil, brought about and ever going on by atmospheric agencies and changes, rain being the principal agent, seems a correct statement to make. But as to *how* and *why* this soil came into existence and grows, those who have studied the matter do not appear to be agreed or to have found a fully satisfactory answer: for instance, one student would attribute the phenomena chiefly to the action of worms; another, to ants, beetles, etc.; a third, to plant-decayed vegetation; a fourth, to rock-weathering; a fifth, to rain. Without doubt, all of these have been more or less instrumental in soil-making, while the last —rain—would seem to be the *one thing needful*—the essential agent.

Now it seems to me that additional light may be obtained on this interesting subject if we consider it as follows:—

(1) I postulate that for every soaking or even moistening of the surface by a shower of rain or snow, etc., which is followed by a spell (whether short or long) of bright and warm weather, *evaporation* is caused.

(2) That such periods of evaporation imply *a rising upwards of a portion of the water through the soil*, to escape as vapour.

(3) That if such evaporation goes on after each shower or storm, there is ever going on in the soil a downward and upward gentle and invisible flow or movement of moisture, which pervades every particle of the soil-forming materials, in manner somewhat analogous to the flow of sap in a tree.

(4) That water flowing or soaking among rock-particles and remains of animal and vegetable substances must ever be changing its chemical composition, and also that of the ingredients of the soil; therefore, the constant up-and-down creep or pulsative action of the moisture through the solids of the soil must be working a gradual change in the chemical and the physical condition of

the soil, no matter how slowly or feebly the process operates or proceeds.

(5) That such implied decomposition, deformation, destruction, reunion, and new combinations of particles and substances of the soil explain why some soils are more fertile than others where science fails to find any difference in them; while others prove less fertile than experiment would indicate or suggest.

(6) That the almost daily recurring changes of weather and less frequent seasonal changes, both as to temperature and humidity, with the help of animals, decay and finally crumble and disperse exposed wood, etc., until it is gone, and suggests how thoroughly the same repetition of precipitation and evaporation is also working, though unseen, just below the grass.

If this incessant oscillating or slow-motion progress of the water through the soil be a fact, then I should suppose that where it has operated with greatest vigour, there, other things being equal, would the soil be thickest and most productive; and *vice versâ*, where the surface evaporation was most sluggish. Possibly the heavy rains and intervals of high temperature of the tropics account for the great fertility of their soils as much or more than for their richness as regards composition.

It will thus be seen that the leading idea in these propositions is *evaporation*—the upward motion (capillary attraction) of the contained-water of the soil working upon the inorganic and organic solid constituents of it, *in conjunction with the descent of moisture* in the forms of rain, snow, fog, etc.

W. S. Gresley.

P.O. Box 437,
Erie, Pennsylvania, U.S.A.

SECTION EXPOSED AT THE DRY DOCK, TROON, AYRSHIRE.

Sir,—The section of rocks exposed in the Dry Dock being constructed at Troon, Ayrshire, may be worthy of preservation in the Geological Magazine. It is as follows:—

	Feet.
A. "Forced" or Artificial material	8
B. Bedded, coarse-grained trap	8
C. Volcanic dust	7
D. ,, ,, bluish	1
E. Grey, fine-grained, banded rock	1½
F. Water of Ayr Hone stone (seen)	8

A. Consisted of general rubbish, with fragments of pottery, etc., but not very old.

B. Towards the north end of the dock works this bed was much thicker, having apparently at that point *cut out* the beds below it to some depth, the "bedding" of the *upper* part of *the trap* being quite regular.

C. This bed had at one time been worked in a pit, the dock works having cut through the old workings. Six feet was the depth of the bed taken out by the pit, the working places being about fifteen feet wide. Nothing historical is preserved as to this pit, but there is a tradition that contraband goods were hid in the workings, and the material from the mine—which has been called "china

clay"—exported to France. About the middle of the dock works this so-called "china clay" was yellowish at the top part, whitish in the middle, and bluish at the bottom. It is exceedingly fine-grained, can be scratched with the nail, and falls to powder readily on exposure to the weather; but when put into an open fire and raised to a good red heat it will scratch glass.

D. This bed is perhaps just an extra-dark band of C.

E. Transition bed from D to F.

F. This bed does not differ from the real *Water of Ayr Hone* or *Whetstone*, and has already gained a reputation as a whetstone and polisher. It is of various shades of colour from light grey to dark grey—the lighter the colour the softer the material—but they all show the peculiar "mirl" of the Water of Ayr stone. Bed E has also this "mirl," showing that it is a transition stage between the "china clay" and the "Hone" bed.

All the beds below the trap exposed in the dock works are perhaps just fine volcanic dust deposited in water, and some of them are more or less stratified, although the stratification is often very faint.

The Hone bed contains nodules of a greenish material with a little *pyrites* and *mica* (white), some of the nodules showing concentric rings towards the outside; and the bedding planes of E have a slight sprinkling of mica.

The trap B is probably an intrusive bed—Whin Sill—and has hardened the "china clay" at its junction with that material. This hardening is well seen towards the north end of the dock, where the clay has been somewhat mixed up with the trap. On the west shore of Troon Point, trap, very coarse in appearance from weathering, is also seen at one or two points to have clay inclusions, the clay in both the above cases being converted into *hornstone* or *porcellanite*, and this substance, like the heated clay, also scratches glass.

The position of the beds is somewhere in the Upper Coal-measures (of Scotland).

The Water of Ayr Hone-bed crops out near Carreath, three miles east from the dock section, and is at present worked in two places, on the Ayr Water to the south of Torbolton, as a polisher and whetstone, ten miles south-east from the dock section. This seems to point to a powerful Carboniferous volcano having existed in the neighbourhood, the fine dust from which appears to have been deposited in pretty still water (probably fresh). Ferns (which I have seen) have been found embedded in the Hone-stone at the Water of Ayr Works.

In the dock section I observed no organic remains, but some parts of the "china clay" bed have faint light-coloured markings, suggestive of worm-tracks. JOHN SMITH.

P.S.—On Saturday last a number of the members of the Geological Society of Glasgow, at my invitation, visited the Troon section and were much pleased with what they saw, the Hone or Whetstone bed being an entirely new deposit to all of them.—J. S.

MONKREDDING, KILWINNING.
14*th March*, 1898.